A META-ANALYSIS OF WORK SAMPLING STUDIES PRE- AND POST-IMPLEMENTATION OF BEDSIDE COMPUTER CHARTING IN INTENSIVE CARE UNITS

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

IN THE GRADUATE SCHOOL OF THE

TEXAS WOMAN'S UNIVERSITY

COLLEGE OF NURSING

BY

PAMELA DYCHE SALYER, M.S.

DENTON, TEXAS

AUGUST 1994

TEXAS WOMAN'S UNIVERSITY
DENTON, TEXAS

May 11, 1994
DATE

To the Associate Vice President for Research and Dean of the Graduate School:

I am submitting herewith a dissertation written by

Pamela Dyche Salyer

entitled A Meta-Analysis of Work Sampling Studies Pre- and Post-implementation of Bedside Computer Charting in Intensive Care Units

I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Nursing.

DEDICATION

I wish to dedicate this dissertation to my parents:

Dr. Charles Preston Salyer, M.D.

and

Bobbie Dyche Salyer, R.N.

in appreciation for a lifetime of personal encouragement and professional example, and most of all for teaching their children that success is an outcome, not a goal.

ACKNOWLEDGEMENTS

I wish to acknowledge Linda Maurer, my manager and friend, without whose understanding and support I could not have completed this dissertation. Often pushed to balance scheduling of time for my student needs against her needs for me as an employee, Linda was always fair, and generous where possible. I greatly appreciate her support.

I also wish to acknowledge the support of Dr. Rebecca Krepper, my dissertation committee chair, for her tireless efforts, availability, encouragement, patience, and wise counsel as I progressed through my research. No less supportive were my other two committee members, Dr. Anne Young and Dr. Lynn Wieck. I thank them all for going above and beyond the call of duty to make my dream a reality. I shall remember them always and fondly.

A META-ANALYSIS OF WORK SAMPLING STUDIES PRE- AND POST-IMPLEMENTATION OF BEDSIDE COMPUTER CHARTING IN INTENSIVE CARE UNITS

BY

PAMELA DYCHE SALYER, M.S.

ABSTRACT

The purpose of this meta-analysis was to integrate the findings of unpublished work sampling studies to determine (1) the effect of bedside computers on the distribution of time nurses spend in direct patient care, indirect patient care, charting, and communication, and (2) the relationship between the effects of bedside computers and methodological characteristics of the primary studies.

The sample included three work sampling studies that measured the impact of bedside computers on the distribution of time that nurses spend in various activities in the intensive care units (ICUs). Analyses began by coding the observations recorded in the primary studies and combining them into the four activity subsets of interest to this meta-analysis. Percent change in time that nurses spent in each activity after computer installation was converted to an effect size through probit transformation techniques. Obtained effects sizes were weighted for sample size and then combined to create a weighted mean effect size for each activity subset across studies.

Findings revealed that bedside computers had no real effect on the time that nurses spent in direct patient care, indirect patient care,

charting, and communication activities when effect sizes were compared to Cohen's guidelines for effect size interpretation. There was an average increase of 2.1% in time spent in direct patient care activities and an average decrease of 2.7% in time spent in charting.

The methodological characteristics considered in this study were (a) prior use of computers, (b) computer applications, (c) length of time between pre- and post-study, and (d) quality of the primary studies. After coding the primary studies, only length of time between the pre- and post-study was found to vary across studies.

A Pearson Product-Moment correlational analysis was conducted to determine the relationship between length of time between the pre- and post-studies and the weighted effect sizes for direct patient care and charting activities. There was found to be no significant relationship between length of time between the pre- and post-study and the weighted effect sizes for direct patient care or charting.

TABLE OF CONTENTS

LIST OF TABLES

TABLE

LIST OF FIGURES

FIGURE

CHAPTER I

INTRODUCTION

Florence Nightingale, in Notes on Nursing (1860), described the importance of the nurse, who is at once a careful observer and a clear reporter. Throughout the ages, nurses have recorded their observations and the performance of their duties, and in so doing have left an indelible record of an expanding profession with ever-increasing demands for documentation (Study Group on Nursing Information Systems, 1983).

Today, it is estimated that nurses spend up to 40% of their productive time in the collection, manipulation, and communication of information, yet little advances have been made in improving the management of information in nursing (Sinclair, 1991). Given that nursing represents an average of 40-60% of a hospital's annual operating budget, it is little wonder that nurse executives are looking for ways to improve and support nursing documentation, while enhancing the productivity of nurses in the clinical setting (Sinclair, 1991). Increasingly, executives are viewing automated bedside charting systems as an attractive solution to the information management crisis in nursing (Simpson, 1992). But, despite the intuitive appeal of bedside computers, limited resources demand that these systems be cost justified (Dennis, Sweeney, MacDonald, & Morse, 1993; Staggers, 1988).

Cost-benefit surfaces as the primary factor with which hospital administrators grapple as they make decisions regarding the implementation of point-of-care technology. Yet, few empirical studies have been done to quantify the effects of bedside computers on nursing documentation, and fewer still have been done to show the effects of bedside computers on nursing practice (Dennis, Sweeney, MacDonald, & Morse, 1993; Staggers, 1988). Many of the hospitals that do empirical studies as part of their justification for bedside computers never publish their findings, and the studies that have been reported are generally individual hospital evaluations of a single implementation experience, with limited relevance to another hospital that is planning to implement a system.

Hendrickson and Kovner (1990) have stated that what is needed is a systematic investigation, across institutions, and at a component level, to form conclusions about the effects of computerization on nursing time. Staggers (1988) has also stated that more and larger studies are needed to determine the impact of computers among different groups of nurses and to factor out changes that are solely due to the introduction of computers from other factors that are at play in the environment. It is this type of integrative inquiry that the investigator has undertaken, through a meta-analysis of work sampling studies conducted in hospitals pre- and post-implementation of bedside computers, to determine the effect of bedside computers on how nurses distribute their time among the activities they perform in an intensive care unit. Further, an attempt was made to identify possible mediating effects in the environment.

Problem Statement

The purpose of this study was to integrate the findings of several unpublished work sampling studies to determine (1) the effect of bedside computers on the distribution of time nurses spend in the performance of certain activities in an intensive care unit and (2) the relationship between the effects of bedside computers and methodological characteristics of the primary studies.

Rationale for Study

The nursing process is an intellectual endeavor that requires the integration, interpretation, and communication of vast amounts of clinical information (Zielstorff, McHugh, & Clinton, 1988). Indeed, nurses spend up to 15% of their time charting (Gwozdz & Togno-Armanasco, 1992; Miller & Pastorino, 1990). In such an environment, computerization of nursing records is being viewed increasingly as a necessity, rather than an interesting option.

In a recent survey of chief nurse executives, 93% of the 340 respondents said that an automated medical record was either absolutely essential or important, yet 62% of these same respondents stated that they did not have computer support for information management in nursing (Simpson, 1992). It is estimated that only 3% of American hospitals with greater than 100 beds have installed computerized documentation systems in nursing (Meyer, 1992). While hospitals typically spend approximately 3% of their annual budget on computer technology (Simpson, 1992), little of that capital has traditionally been spent on computerization to support the largest and most costly of the institution's workforce - nursing (Martin & Baker, 1993).

As nursing practice has expanded, so too has the requirement for nursing documentation. Fischbach (1991), in a review of nursing documentation, found that nursing records mirror the trends and issues in the healthcare profession, with nurses notes being written to support legal, ethical, financial, reimbursement, private and government insurance review processes, nursing standards, research, education, and now quality improvement. But Fischbach also found that even though the volume of charting has increased and the methods of charting have changed over the years, the problems inherent in manual charting have remained consistent. In 1928, Margaret Buscke (cited in Fischbach, 1991) wrote that nursing records suffered from ambiguity, lack of clarity, illegibility, and incompleteness; the same problems present in nursing records to this day. It is little wonder that increasingly, hospital administrators and government agencies are at least considering automated records as a means to streamline the documentation process, while making vital clinical data more widely accessible through technology (Meyer, 1992). But these systems are expensive, with price tags ranging from $2,000 to $30,000 per bed (Meyer, 1992). Justifying the cost of these systems is paramount in an era of scarce resources, and empirical studies are needed to determine the actual benefits of the systems (Staggers, 1988).

Staggers (1988), in a review of the literature regarding computers in nursing, found that there were few published empirical studies to support the anecdotal claims that computers increase the productivity of nurses. More recently, Lower and Nauert (1992) and Martin and Baker (1993) have reported that there is little empirical data in the published literature that provides a systematic evaluation of the actual benefits to nursing that have been derived by installing bedside computers for nursing documentation. Yet, empirical studies have been done by hospitals as they install clinical computer systems; they simply too often do not publish the results.

Curlette and Cannella (1985) reported that often researchers are hesitant to publish studies that were conducted solely for the benefit of an institution, or if the results of the study were not significant or as hypothesized. Staggers (1988) found that if a computer benefits study is conducted by a hospital, it often is not published because the hospital considers the information confidential or too institution-specific. The wealth of unpublished data to support the acquisition and installation of computers in nursing is potentially significant and can be greater still if individual studies can be obtained and integrated to increase the size of the samples and the scope of the evaluation. Therefore, the intent of this study was to conduct a meta-analysis of unpublished hospital-based work sampling studies that document the effect of installing a bedside computer system for nursing documentation.

Theoretical Framework

Ludwig von Bertalanffy is generally credited with development and promotion of General Systems Theory (Hazzard, 1971; Pierce, 1972; Putt, 1978). Von Bertalanffy was a theoretical biologist who became disenchanted with the mechanist-vitalism theories of the 1920's. For over ten years, he studied the growth, metabolism and biophysics of living organisms within a framework that he termed an organismic view. His seminal work was based on the concepts of steady state and open systems. Further reduction and generalization of these concepts became known as General Systems Theory. Von Bertalanffy first presented his ideas in 1937 (Pierce, 1972). In 1954, when the Society for General Systems Research of the American Association for Advancement of Science was established, the concepts of the theory were formalized (Putt, 1978).

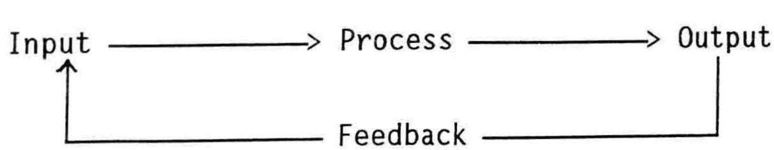
Two important concepts in General Systems Theory are system and environment. System may be defined as a whole consisting of a set of component parts that mutually react (Putt, 1978). The environment of a system consists of all factors that affect the system and all factors that are affected by the system (Hazzard, 1971). The distinction between what is system and what is environment is often situational. In one situation the system might be a nurse whose parts include arms, legs, and brain and whose environment is a nursing unit, while in another situation, the system might be a nursing unit whose parts include patients, nurses, ward clerks, and nurse aides and whose environment is the hospital. The situational nature of system and environment stems from the fact that systems are hierarchical in nature; they consist of subsystems and are part of suprasystems, each defined by a boundary (McKay, 1969).

A boundary is the line of demarcation between a system and the environment. The boundary must encompass all of the components of the system and may be thought of as more or less permeable (Hazzard, 1971). The degree to which a system boundary is permeable defines the nature of the system. A system whose boundary permits continuous interchange of energy, information, and matter between the system and its environment is called an open system. The boundaries of open systems are dynamic and change in response to strain or stress. A system whose boundary does not permit exchange between the system and environment is called a closed system. The boundary of a closed system is rigid, effectively sealing the system off from its environment (Putt, 1978).

All living organisms are open systems that enter into an exchange with the environment (von Bertalanffy, 1968). This exchange stimulates the internal components of the overall system. Activity requires that energy be shared or changed in form and location. Exchanges of energy can occur at a rapid rate or can be very slow, with some exchanges being reversible and others irreversible. By absorbing energy, all systems have the potential to evolve. Evolution, in systems terms, refers to the tendency toward increasing complexity and higher organization. Conversely, all systems have the potential for increasing their disorder or disruption through the dissipation of energy, a process called entropy. Evolution leads to growth of the system, while entropy leads to ultimate system mortality (Putt, 1978). Systems tend to move toward a dynamic balance between evolution and entropy in a process of self-regulation known as steady state (Hazzard, 1971).

Von Bertalanffy (1968) asserted that steady state is a characteristic of all open systems. In the steady state, variables tend to remain within a predetermined range of system parameters, although the value of the system variables may change as the result of alteration in ability to process energy, matter, and information. Energy, matter, and information are known collectively as input when they enter the system and as output when they leave the system. Input flows into the system from the environment, causing a reaction that may produce components of higher complexity or greater disorder (Hazzard, 1971). The system acts and reacts as a whole; a dysfunction in one part creates a disturbance in the system rather than the loss of a single function. To facilitate self-regulation, systems contain a feedback loop that permits a portion of the system output to return to the system, where it provides additional information that can be used by the system to adjust its output. The process is dynamic and tends to be cyclical in nature, with a continuous flow of inputs, process, outputs, and feedback that maintains the steady state (Hazzard, 1971). A visual model of this process is presented in Figure 1.

Figure 1. Model for General Systems Theory



A final concept that is important in General Systems Theory is equifinality. This term implies that an end or characteristic state can be achieved in all open systems independent of the starting point or means employed. In other words, equifinality suggests that the same end can be achieved by different approaches and from different initial states or conditions (Putt, 1978). This concept is important when one considers the energy loss incurred by a system during the process of maintaining a steady state or during periods of increased stress or strain. Survival of a system is dependent upon replacement of lost energy (Hazzard, 1971). Equifinality suggests that this end may be achieved by many means and independent of the level of energy depletion when intervention begins. If loss of energy can be checked, a variety of interventions can effectively be employed to bring about a desired result.

General Systems Theory has great relevance in the field of nursing as a framework to explain phenomena. Relevant to this study, General Systems Theory and its concepts serve well to assist in describing the impact of a bedside computer system on nursing practice.

A nurse in an intensive care unit is an example of an open system in dynamic interaction with an environment that includes patients, families, physicians, a variety of ancillary and support personnel, other nurses, equipment, and any number of internal and external procedures, policies, standards, and laws, all placing their own demands on the nurse's energy, matter, and information. A central nursing activity in this environment is verbal and written communication between and in support of the many participants in the intensive care unit.

Charting and verbal communication take a great deal of time that might be better spent in direct patient care. Therefore, introduction of computer technology that has the potential to reduce the amount of time that it takes to chart and communicate should affect the proportion of time spent in these activities relative to the time spent in more direct patient care activities. In other words, given no change in the requirements for charting and communication (inputs), a change in the medium for charting (process) might result in a change in the proportion of time spent in this activity relative to other nursing activities like direct patient care (outputs). The redistribution of time is then fed back into the system in the form of new energy, matter, and information, positive or negative, as the environment seeks to evolve to a new level of steady state.

The current study sought to integrate work sampling studies that had been conducted by hospitals pre- and post-implementation of bedside computer charting in the intensive care units. The primary inputs that influence charting in this environment are stable across institutions and include a variety of medical, legal, financial, quality improvement, regulatory/governmental, and research requirements for documentation. As it is assumed that these types of inputs are common to all intensive care environments, no attempt was made to assess the specific influence of these inputs on the process of charting, but they were addressed at length in the literature review. Other inputs in the form of potential moderator variables were analyzed in the study. These moderator variables include: (a) prior use of computers by the nurses, (b) type of computer applications in use at the time of the post-study, (c) length of time between the pre- and post-implementation study, and (d) quality of the primary studies.

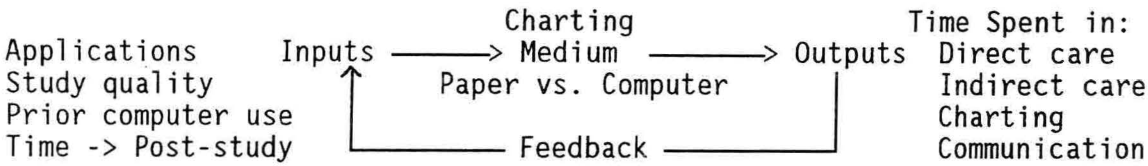
Introduction of computers for charting in an intensive care unit can be considered a stressor, and there will be an initial period of entropy. Nurses who have had some prior interaction with computers in the environment, usually in the form of an order entry and/or results reporting system, may evolve to a steady state more rapidly than those for whom bedside computer charting is the first exposure to computer use. Likewise, as the length of time that the nurses engage in computer charting increases, and the application set becomes more rich with value-added means of charting, integration of the computers into the environment will be enhanced, and evolution toward steady state should progress. As steady state is attained and the use of computers for charting and communication becomes a familiar and valued part of the environment, the time involved in these activities should be affected.

Quality of the primary studies was evaluated as an input because the data to be analyzed is based upon the observations and documentation of an observer of the environment, who is in fact for the period of the observation a part of the environment. Quality was assessed by the documented level of training and interrater reliability testing of the observers who participated in the work sampling studies.

Paper-based versus computerized charting is the process component of the General Systems Model in the study, and it is the process that was manipulated as paper charts were replaced with electronic ones. The change in process should affect the outputs to be analyzed in the study, specifically the proportions of time intensive care nurses spend in such activities as: (a) direct patient care, (b) indirect patient care, (c) charting, and (d) communication.

Using the model for General Systems Theory, the study may be visually depicted as in Figure 2.

Figure 2. General Systems Model of the Study



The application of General Systems Theory to the study of how bedside computers impact the ways in which nurses spend their time is helpful in structuring the inquiry into meaningful units for analysis. Evaluation of moderator inputs further aided in determining why introduction of the same computer system into seemingly similar environments with common requirements for charting may have resulted in different levels of the output variables.

Assumptions of the Study

This study was predicated on the following assumptions:

1. A nursing unit is an open system and has certain characteristics that are basic to all open systems (Putt, 1978).
2. Open systems require interactions with the environment to maintain

order and organization (von Bertalanffy, 1968).

3. Open systems have the potential to alter their structure and behavior in response to situational and developmental stress (von Bertalanffy, 1968).

Research Questions

Research questions to be answered in this study were:

1. What is the magnitude of the effect of bedside computers on the proportion of time intensive care nurses spend in: (a) direct patient care, (b) indirect patient care, (c) charting, and (d) communication?
2. Is there a relationship between the effects of bedside computers and the methodological study characteristics: (a) prior use of computers, (b) type of computer applications in use at the time of the post-study, (c) length of time between the pre- and post-implementation study, and (d) quality of the primary studies?

Definition of Terms

For the purpose of this study, the following terms are defined.

1. <u>Bedside computer</u>: a computer workstation consisting of a central processing unit, keyboard, mouse, monitor, and software that is installed at a patient's bedside for the purpose of documenting and reviewing patient data. For the purpose of this study, the bedside computer was a Unix-type IBM or Sun workstation running the System

2000 clinical information system software on a local area network and interfaced to a physiologic monitor for automatic acquisition of vital signs and hemodynamic data.

2. Charting: time spent with paper, including writing, reviewing, and straightening paperwork (Halford, Burkes, & Pryor, 1989). For the purpose of this study, charting was measured by documenting in a codebook the charting activities observed and coded in the primary work sampling studies.

3. Communication: any verbal transaction between the nurse and doctors, patient family members, and other staff, either in person or on the telephone (Halford, Burkes, & Pryor, 1989). For the purpose of this study, communication was measured by documenting in a codebook the communication activities observed and coded in the primary work sampling studies.

4. Direct patient care: procedures performed or any other contact with the patient at the bedside or in the room (Halford, Burkes, & Pryor, 1989). For the purpose of this study, direct patient care was measured by documenting in a codebook the direct patient care activities observed and coded in the primary work sampling studies.

5. Indirect patient care: any activity performed by the nurse that is not in direct contact with the patient. Any nursing activity that does not meet the definition of direct patient care above. For the purpose of this study, indirect patient care was measured by documenting in a codebook the indirect patient care activities observed and coded in the primary work sampling studies.

6. Methodological characteristics: those variables related to general considerations of the research design and methodology for a given scientific investigation (McCane, Smith, & Abraham, 1986). For the purpose of this study, methodological characteristics of the research environment were coded in a codebook and included the variables: (a) prior use of computers, (b) type of computer applications in use at the time of the post-study, (c) length of time between pre- and post-implementation study, and (d) quality of the primary study.

Limitations

A limitation of the study is that only users of the System 2000 bedside computer system, installed in an intensive care unit, and operating on powerful UNIX-type workstations, were included in the study. Therefore, findings may not be directly generalized to users of other bedside systems, particularly PC-type systems installed in general care environments.

Summary

As the requirements for nursing documentation increase, the desire for some means to ease the burden through automation becomes more attractive. Computerized nursing documentation systems, particularly bedside systems, are very expensive and must be cost justified. Yet there is little in the published literature that provides empirical support for the anecdotal claims that bedside systems increase nursing productivity. Those hospitals who perform a benefits realization study pre- and post-implementation of a bedside charting system often do not publish their findings. Reasons for not publishing include believing that the research is for the benefit of the institution only or is too institution-specific, and/or feeling that the results are too confidential for publication. These unpublished studies offer an untapped source of valuable information in and of themselves, but the information they may offer can be further enhanced if the results of these independent studies are pooled to increase their sample size and the scope of their analysis.

The current study was based upon principles of General Systems Theory and utilized the techniques of meta-analysis to integrate unpublished hospital work sampling studies that were conducted pre- and post-implementation of bedside computer charting. The results of the meta-analysis describe the effects of bedside computer charting on the time intensive care nurses spend in the performance of various nursing activities. The results also describe the relationship between methodological characteristics of the primary studies and measured effects of bedside computer charting.

CHAPTER 2

REVIEW OF LITERATURE

Donna Shalala, U.S. Secretary of Health and Human Services under the Clinton Administration, has written, "I cannot think of a profession that has changed more in a generation than nursing" (1993, p. 289). In contrast, Dr. Ralph Korpman, a nationally recognized expert in clinical information systems, contends that, "the paper medical record hasn't changed substantially in 100 years" (Dunbar, 1991, p. 31). In a recent evaluation of patient charts, it was found that fully 50% of the forms in the medical record are the responsibility of nursing (Raygor, 1994). Perhaps more by default than design, a large part of the change in nursing over the last generation is that nurses have become the information hub in healthcare, assuming responsibility for documentation and management of the vast amounts of information that make up a patient's medical record.

The medical record is the focal point of a number of disparate groups, including nurses, physicians, patients, attorneys, third party payors, private and governmental regulatory agencies, and increasingly, consumers (Huffman, 1981). The growing demand for the collection and management of information to support the legal, regulatory, clinical quality, and financial aspects of patient care is one of the greatest challenges faced by practicing nurses (Gwozdz & Togno-Armanasco, 1992). The effect of this demand is greater still in a healthcare environment where patient acuity is increasing on average 3% a year (Meyer, 1992).

Sovie (1989) has described the current environment as being in crisis. But she then reminds us that crisis, when written in Chinese, is depicted in two characters: one meaning threat and the other opportunity.

In this chapter, both the threats to and opportunities for nursing documentation will be reviewed within a framework of General Systems Theory. Inputs in the form of requirements for nursing documentation will be reviewed, followed by an overview of processes by which nurses have attempted to streamline manual charting and achieve process improvement through automation, and concluding with a review of empirical studies that have measured the outputs, or effects, of computerized nurse charting.

Inputs: Principle Requirements for Nursing Documentation

There are many requirements for nursing documentation, however principle among these are the needs to satisfy legal, regulatory, quality improvement, and financial initiatives. It is these initiatives which most influence the content and structure of nursing documentation, and thus provide the primary inputs to the process of nurse charting. A review of the principle legal, regulatory, quality improvement, and financial requirements for nursing documentation follows.

Legal

Hospitals and other health care institutions are required by law to maintain medical records. These requirements are found in either statute or administrative regulations in every state, and often rely on the standards produced by non-governmental sources, such as those set by the hospitals themselves, accreditation groups, and professional organizations, to lay the framework for what the record should include (Huffman, 1981).

Approximately 90 to 95 percent of the activities involved in a patient's care are reflected in the medical record, and since documentation by nurses comprises a large part of a patient's chart, legal considerations of nursing documentation have always been important (Albarado, McCall, & Thrane, 1990). The legal concern over nurse charting gains importance when one considers that approximately one out of four malpractice suits is decided from the patient's chart (Edelstein, 1990). The medical record is almost always used to support bodily injury and malpractice claims (Fracassi, 1987) and is the primary source document used by the courts to substantiate and assess what actually occurred during the course of a patient's care (Huffman, 1981).

Courts now hold nurses liable for their own actions as evidenced from the written record of their interactions with and planning for the patient. Therefore, the nursing record must be complete, clear, and logical, with any errors marked appropriately (Edelstein, 1990). The record must also demonstrate that the healthcare professional provided a reasonable standard of care; a standard outlined by the profession, through professional practice acts; the hospital, through policies and procedures; and regulatory agencies, through definition of minimum standards of care (Huffman, 1981).

Regulatory

Regulatory standards define acceptable performance and assign accountability (Macklin, 1990). Efforts to establish a minimum standard for performance in hospitals began in 1912, when the Third Clinical Congress of Surgeons of North America resolved that:

> some system of standardization of hospital equipment and hospital work should be developed, to the end that those institutions having the highest ideals may have proper recognition before the profession, and that those of inferior equipment and standards should be stimulated to raise the quality of their work. In this way patients will receive the best type of treatment, and the public will have some means of recognizing those institutions devoted to the highest ideals of medicine (Macklin, 1990, p. 249).

In the ensuing years, hospitals have adopted a variety of standards in an effort to regulate the provision of healthcare and assure some measure of quality in that care. While standards may be defined by hospitals themselves, they are more often dictated by external regulatory agencies. Of those agencies who set standards, perhaps none has had a greater impact on hospitals than the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), whose standards are based upon professional practice acts (Patterson, 1990), and on whose approval the financial viability of healthcare organizations rests (Mahrenholz, 1992).

Since its founding in 1951, the JCAHO has become the principle standards setter for hospitals (American Organization of Nurse Executives [AONE], 1992). Additionally, in 1965, accreditation by the JCAHO became a requirement for reimbursement under the federal Medicare and, in many states, Medicaid programs, making JCAHO accreditation essential for the financial health of healthcare organizations (Mahrenholz, 1992; Rockwell, Pelletier, & Donnelly, 1993). JCAHO regulates hospitals through standards setting, education, and triennial on-site evaluation of performance against their standards (AONE, 1992).

The JCAHO standard for nursing documentation is the primary influence on what and how nurses chart. The standard places great emphasis on the nursing process, requiring that "nursing care related to patient assessments, the nursing diagnosis and/or patient needs, nursing interventions, and patient outcomes are permanently integrated into the clinical information system (for example, the medical record)" (JCAHO, 1994, p. 142). While the JCAHO nursing standards no longer require a formal care plan, nursing documentation must show evidence that care was planned as part of the nursing process, and that patient education and discharge planning occurred (Krum, 1991).

To facilitate compliance with the JCAHO standard for nursing documentation, nurse administrators have developed elaborate forms and formats to assist staff in meeting JCAHO requirements in the most efficient way. Charting policies, forms, and formats have been designed not only to facilitate documentation of the nursing process, but to aid in the more difficult task of abstracting the data for review

(Schoessler, 1991). This process has been expensive and time-consuming, and more expensive still in the final preparation for the chart review conducted during the JCAHO on-site survey (Rockwell, Pelletier, & Donnelly, 1993). However, recent changes in the Commission promise to make the "paper-chase" for JCAHO even more critical and more labor intensive in the future.

In 1987, the JCAHO announced a bold new initiative call The Agenda for Change, which became effective in January, 1992. With The Agenda for Change, the attention of the JCAHO shifts from a review of policy and procedure manuals, which promise a standard of quality if followed, to more face-to-face interviews and reviews of documentation, which evidence the actual practice and outcomes of care. The foundation of the Agenda for Change is the adoption by the JCAHO of the principles of Continuous Quality Improvement (CQI) (JCAHO, 1990). This approach in effect mandates that hospitals wishing to achieve accreditation must adopt a very specific method of monitoring and evaluating quality. Implementation of CQI dramatically affects the requirements for nursing documentation and the process for review of that documentation (Moreland, 1991).

Continuous Quality Improvement

Few initiatives have affected a hospital's requirements for the collection, management, and retrieval of clinical information to the extent that Continuous Quality Improvement (CQI) has (Dick & Dalton, 1994). CQI is a specific process of evaluation and monitoring of data in the form of indicators of quality. As the JCAHO adaptation of CQI is the one that most directly impacts requirements for nursing documentation, it is the JCAHO process for monitoring and evaluation for CQI that will be described here.

The JCAHO has mandated that hospitals develop a CQI-grounded monitoring and evaluation program that is planned, systematic, and ongoing (Claflin, 1991). The addition of monitoring and evaluation activities for CQI does not replace a hospital's obligation to comply with JCAHO's standards for survey and accreditation, but rather adds an additional requirement for accreditation (JCAHO, 1990).

Documenting and assessing the quality of care under a CQI-based program requires documentation of considerably more clinical data and in ways that challenge our current means to collect, manage, retrieve, and evaluate data. Documenting under CQI requires integration of data produced by the various care givers with whom a patient comes in contact, to produce an integrated record of the process of care, not the discreet actions of individual departments. CQI requires organization of data around work processes instead of departmental boundaries (Minard, Girotto, Andrews, & Salyer, 1994).

Nursing, as the information hub in healthcare, is a key player in a hospital's CQI program, and is essential in its documentation of the process(es) and outcome(s) of patient care. Charting against new practice guidelines and indicators has added significantly to the requirements for and time involved in nurse charting. This added responsibility, coupled with the fact that monitoring of indicators must be continuous, has led many nursing departments to develop special forms to be used for the primary collection of CQI data or the secondary recording of data abstracted during audits of primary sources (Schoessler, 1991). This process is expensive and labor intensive largely because of nursings' reliance on a paper chart.

Dick and Dalton (1994) cite several problems with trying to manage CQI in the world of the paper-based patient record (PPR). Data in a PPR tend to be structured along departmental lines, are often illegible, redundant, or even missing. Most problematic is that the data are not in a machine readable format. Therefore, data must be manually abstracted for integration, aggregation, and review, or worse, require that indicator data be collected on a separate form. CQI places strong emphasis on the graphical display of data, which requires in a PPR environment that data be gleaned from the chart and graphed as an independent activity, adding to the time and effort required to satisfy CQI initiatives. All of this effort adds overhead and cost to hospital operations, a cost that Dick and Dalton (1994) believe could be off-set by implementing a computer-based patient record (CPR).

A CPR allows data to be entered by clinicians in more traditional ways, because the computer can manipulate and aggregate the data to effect integration for process monitoring as a by-product of processing, rather than an independent event. Data are in a machine readable format and can be abstracted for use in a variety of ways, including graphical displays and export to external data-bases, such as those being proposed by the JCAHO and healthcare reform plans (Dick & Dalton, 1994). One of the greatest advantages of a CPR over the PPR is that in an automated record, quality data can be linked directly to cost data; an essential requirement in this era of quality monitoring and cost containment.

Financial

Review of nursing documentation for substantiation of patient charges has been a practice of third party payors and internal auditors for many years, and so has made an accurate and timely chart important to the financial aims of a hospital (Huffman, 1981). Since nursing is responsible for more than 50% of the information in a patient's chart (Mowry & Korpman, 1987), nursing documentation has traditionally played a key role in financial audits. However the demand for nursing documentation to support the financial aims of a hospital is becoming more critical in today's environment of cost containment and healthcare reform.

Hillary Rodham Clinton, chairman of the Clinton Administration's Health Care Reform Committee, on the occasion of the National League for Nursing's 100th anniversary, wrote "whether as staff nurses, advanced practice nurses, or primary care providers, nurses are critical to the changes our country must make" (1993, p. 288). Sherer (1993) has written that nurses under healthcare reform will take on more responsibility for cost-control in clinical practice as cost-containment moves closer to the bedside. Nurses will be called upon to manage scarce resources and to anticipate and try to avert situations that might lead to delays in discharge; all the while nurses must continue to promote the highest standard of quality for patient care.

Providing the best possible care for the least possible cost requires continuous vigilance in documenting and assessing information related to practice, resource utilization, and patient outcomes (Simpson, 1994). To facilitate this, nursing departments have attempted to organize and structure documentation for ease of entry and ease of retrieval. These process improvements in the documentation process can be accomplished by utilizing better formats for the paper-based patient record (PPR), or by implementing a computer-based patient record (CPR).

Process: Manual versus Computerized Nursing Documentation

Fischbach (1991) has written that nurses notes mirror the trends and issues in healthcare. Beginning with full narrative notes, nursing documentation has evolved over time to newer and better formats in an attempt to streamline charting and facilitate the abstracting of data. While there have been many forms of manual charting over the years, this section will review three of the newer formats that have proven to produce process improvements in today's environment and lend themselves to future automation in support of CQI and reform initiatives. These include: 1) flowsheets, 2) PIE (Problem Intervention Evaluation) charting, 3) and Charting by Exception. The section will conclude with a review of literature related to computerized nurse charting.

Paper-based Charting

Flowsheet charting was originally developed for use in an intensive care unit, but is being used increasingly in medical-surgical and outpatient areas. A flowsheet is in the format of a matrix, with tasks to be accomplished on the Y axis and times on the X axis. Nurses simply indicate the completion or outcome of a task by entering an appropriate data value in the cell that intersects the task with the appropriate time column. A detailed flowsheet has two primary advantages: 1) it eliminates the need to write extensive nurses notes and 2) it eliminates duplication of information (Fracassi, 1987).

Fracassi (1987) states that a well designed flowsheet can increase efficient use of time and enhance accuracy and legibility. A flowsheet is particularly helpful in recording ongoing data collection, such as I&O, vital signs, weights, treatments, and assessments.

Smith, LaFoy, Macklin, and Minors (1991) reported that after implementation of a unit specific flowsheet at St. Joseph's Hospital in Atlanta, there was an overall increase in compliance in charting the elements of the nursing process, as prescribed by nursing policy. Compliance in the narrative notes prior to implementation was 31.5% and increased to 59.1% with use of a flowsheet.

Implementation of a flowsheet at Community Memorial Hospital in Toms River, New Jersey, resulted in a time savings in charting, as evidenced by a significant reduction in the amount of overtime attributed to documentation activities. One observed advantage to the flowsheet was ease of documentation on a continual basis throughout the shift, resulting in better documentation and less time spent in completing documentation at the end of the shift. This factor alone resulted in a savings of 34 hours per pay period in overtime payments (Fracassi, 1987).

PIE charting originated in 1984 at Craven County Hospital in New Bern, North Carolina and was designed to provide an ongoing plan of care that was actually used. It incorporates the nursing process into daily documentation (Kerr, 1992; Siegrist, Dettor, & Stocks, 1985).

PIE charting begins with a thorough patient assessment. Hospitals use their own assessment forms but are encouraged to also use checklists and flowsheets. A separate care plan is not used, as care planning is demonstrated through recording of interventions in the nurses notes. Problems that are identified from the assessment are listed and numbered on a problem list each 24-hour period. The problems, interventions, and evaluations (PIE) are then described in narrative notes in the PIE format, referring to problems by their number (Kerr, 1992).

Kerr (1992) reports that the advantage of PIE charting and the feature which saves nurses time, is that a separate care plan is not necessary. Siegrist, Dettor, and Stocks (1985) reported that implementation of PIE charting at Craven County Hospital resulted in better documentation and required less time for the nurses to chart. The format also enhanced retrieval of data specific to a problem or the steps in the nursing process relative to that problem. Most importantly, its emphasis on the nursing process makes compliance with JCAHO standards for documentation easier to attain.

Charting by exception was created at St. Luke's Medical Center in Milwaukee, Wisconsin, in 1983, with the goal to eliminate lengthy narrative notes. In this model of charting, nurses write a narrative note only for those items that are exceptions to a defined norm (Kerr, 1992).

Murphy and Burke (1990) describe charting by exception as a shorthand method for documenting normal findings, based on clearly defined standards of practice and predetermined criteria for assessment and intervention. The model begins with use of an innovative patient assessment form, on which all normal parameters for each body system are defined. If the patient's findings fall within the range of normal for a given parameter, the nurse only needs to place a check mark. An abnormal finding is denoted by entry of an asterisk, which directs the reader to look for a narrative note (Kerr, 1992).

The concept of charting with check marks and asterisks defined on the assessment form carries over to the other forms in the chart. Relatively few narrative notes are required, as only deviations from the norm are addressed. The system does include a care plan, but again entries are brief (Kerr, 1992).

At Marquette General Hospital in Michigan, implementation of charting by exception resulted in a time savings of 23% on the day shift, 24% on the evening shift, and 35% on the night shift (Welsch & Nicholson, 1991). St. Luke's Medical Center in Milwaukee, Wisconsin, realized a savings of 44% in charting time with implementation of charting by exception (Kerr, 1992). Murphy, Berlinger, and Johnson (1988) reported a savings in charting time of 100 hours per day across all units at St. Luke's after implementation of exception charting.

There is little doubt that process improvements in nurse charting can be made simply by implementing a system of manual charting that demonstrates the use of nursing process, while easing the burden of doing so. However, inherent in any system of manual charting are problems related to legibility, accessibility, and data retrieval (Miller & Pastorino, 1990). The increased demand for information management in these times of cost containment and quality improvement has led many to seek an automated solution to nursing documentation. The decreasing cost of computer hardware and software components is making implementation of automated charting an increasingly feasible and attractive option for the healthcare industry (Meyer, 1992).

Computer-based Charting

Raygor (1994) in a recent study of the paper chart and its potential for computerization found that 97% of the forms in a chart have potential for automation. With automation comes the promise of better documentation (effectiveness) in less time (efficiency). These two dimension of automated charting are most often cited as benefits to the introduction of computers in nursing.

The marriage of computers and nursing began quite literally with a marriage. In 1961, Dr. Donald Bitzer began work on the first plasma panel (display screen) for a computing device in the PLATO Project that he directed. Interest in her husband's work caused Maryann Bitzer, R.N., in 1962, to write a program to be used to teach obstetrical nursing. This project became the seminal work in nursing informatics

(Ball & Hannah, 1984). Since that time, computers have been increasingly introduced in nursing as a means to ease the burden of documentation while yielding a better chart.

Staggers (1988) states that direct benefits of computers in nursing can be organized into two main categories: accountability and efficiency. Concerning accountability, computers can facilitate improvements in the quality, completeness, accessibility, legibility, accuracy, and timeliness of information available about a patient. Concerning efficiency, computers can have a direct impact on the way nurses distribute their time among indirect patient care activities, such as charting, communication, and report, and direct patient care activities, such as the provision of hands-on care. Such outcomes of an automated documentation system make this charting medium an attractive option, but only if these benefits can be realized in some demonstrable and quantifiable way.

Outputs: The Impact of Computers on Nursing Practice

While there are published articles which advance the anecdotal claims that computers can improve the quality of nurse charting and save time, the published literature contains few empirical studies that report direct measurement of the benefits to nursing of automated information systems (Dennis, Sweeney, MacDonald, & Morse, 1993; Martin & Baker, 1993; Staggers, 1988; Welsch & Nicholson, 1991). Still fewer studies are found which assess the impact of computers on nursing service rather than on the quality of the automated chart (Staggers, 1988). Lower and Nauert (1992) note that vendors, in particular, claim that computers can save nurses time, but there are few published reports from unit sources to substantiate such claims. The following is a review of published and unpublished reports which detail direct measurement of the impact of computers on nursing.

Lutheran Hospital in La Crosse, Wisconsin conducted a work sampling study pre- and post-implementation of the Unix-based Hewlett-Packard CareVue 9000 bedside computer system in its 15 bed ICU in 1989 (Allen & Davis, 1991). Observers, described as being nursing and non-nursing, were trained to make observations of nursing activities in the ICU at 15 minute intervals over 24 hours each day for a five day work sampling period in the pre-implementation study, and again five months later in a post-implementation study. Observations were hand recorded on a data collection tool. Although the report does not state whether inter- or intrarater reliability testing was done, the report does state that observers were instructed in the use of the data collection tool and the process of work sampling.

The findings of the Lutheran Hospital work sampling study revealed that charting activities were reduced by 21% after installation of the bedside charting system (Allen & Davis, 1991). Other findings include an increase of 8.5% in time spent in direct patient care activities and a slight reduction in the amount of time spent in indirect patient care activities (-7.8%). The electronic charting system was found to capture over 50% more patient data, and data were more accurate. Nursing overtime for charting was eliminated after installation of the system.

Kahl, Ivancin, and Fuhrmann (1991) assessed the benefits of installing the CliniCom bedside computer system (PC-based) in a medical-surgical environment at St. Joseph's Hospital in Milwaukee, Wisconsin. Benefits were measured by time and motion and cost-benefits studies conducted pre- and post-implementation of the system. Positive benefits of the system noted were in the quality of the automated record, that is, a more accurate, complete, timely, legible, better organized, and accessible record. While they reported some decrease in time spent charting and some increase in time spent with the patient, the time savings they projected with implementation of a bedside system had yet to be realized at the time of the article. Exact time savings were not detailed, but the authors did state that owing to efficiencies gained by use of the automated charting system, the hospital expected to be able to avoid adding 28.5 FTEs to the master staffing plan on some units where patient volumes were budgeted to increase. However, anticipated time savings were not sufficient to allow a decrease in the skill mix of the existing staff, which had been a goal for installing the system. This finding led these researchers to conclude that a bedside system "provides the opportunity for the nurses to be more productive" (Kahl, Ivancin, & Fuhrmann, 1991, p. 398). However, there are no guarantees.

Hendrickson and Kovner (1990), in reporting the results of six computer benefits studies, found that in four of the six studies, time savings in communication was directly attributable to the order entry and results reporting systems. No time savings in communications, nor increases in the amount of communication, could be attributed to automated charting or physiological monitoring systems. These authors also found that only one study reported that time saved by the computer translated into more time spent in direct patient care; two studies found that time spent in direct patient care remained the same; and in two studies it was found that nurses spent less time with the patient after computerization. The authors concluded that on-line charting results in a more complete, legible, and accessible chart, but no real time savings.

Peat Marwick Main and Company (1988), a large certified public accounting firm, conducted a study to determine the effects of installing the TDS Healthcare System (mainframe-based) at three hospitals; The Methodist Hospital, Omaha, Nebraska (ICU); St. Joseph's Hospital, Atlanta, Georgia (med-surg unit); and Frankford Hospital, Philadelphia (med-surg unit). Each hospital selected one test unit for placement of the terminals and one control unit whose characteristics were similar to the test unit. Terminals were placed at the bedside on the test units and data were collected by chart reviews and time and motion studies on both the test and control units over a six month period. Findings were reported in an executive summary of the entire study.

The Peat Marwick Main and Company (1988) executive summary stated that all study sites reported a significant improvement in the quality of the automated chart. Specifically cited were a decrease in errors of omission, an increase in charting of I&O and IVs, greater accuracy and completeness of documentation, improved standardization and quality of charting, more accurate and up-to-date care plans, and greater timeliness of tests and procedures. Medication errors were reduced by 34%, patient calls were reduced by 26% and repeat calls by 50%; discharge teaching documentation was improved by 14%, and IV site assessment was improved by 4%. Findings related to time savings were less dramatic. Productivity improvements averaged 26.12 minutes per nurse/per day/per shift. Time savings ranged from approximately 20 minutes at Frankford Hospital to 30 minutes at Methodist Hospital. Interestingly, the company noted in its report that hospitals that have installed automated information systems at the nursing station may have already realized a significant improvement in productivity and will see less improvement with installation of a bedside system than would be seen in a hospital where no prior automation existed. Peat Marwick Main and Company (1988) concluded that in hospitals where some automation existed at the nursing station prior to installation of a bedside system, productivity gains may represent incremental improvements resulting simply from migration of computers to the bedside. This finding is similar to one noted by Halford, Burkes, and Pryor (1989).

Halford, Burkes, and Pryor (1989) published a work sampling study which measured the impact of migrating an existing computer system from a pod configuration of one computer per four beds in a ward to a bedside configuration. They found that simply moving a system, even the same system, to the bedside resulted in a slight increase in productivity on the nursing unit. Direct patient care was found to increase by only three percent, but time waiting to access a computer dropped by 20%. The time spent in real-time documentation on the computer at the bedside versus in the pod-configuration also increased by 15%. The authors concluded that moving the existing computer system to the bedside resulted in nurses spending less time waiting to chart on a computer, increased the time spent in real-time entries, and increased the time that nurses spent with the patient.

Mowry and Korpman (1987) maintain that since 50% of patient data is collected at the bedside, traditionally on scraps of paper, a simple change of medium for documenting these data may have less to do with the medium than with the proximity of the medium to point of service. Tonges and Lawrenz (1993) also suggest that nurses will not realize the maximum benefit of automation until they go beyond simply automating their existing systems.

Erb and Coble (1989) reported the effects of installing the VitalNet (PC-based) system on a 31 bed trauma unit and a 26 bed cardiac cath unit at Tampa General Hospital in Florida. The VitalNet system is designed to allow automated acquisition of blood pressure and pulse data and is limited to recording vital signs and short note entries at the bedside. By time and motion studies conducted prior to installation and six months post-installation, the hospital determined that each nurse saved approximately 11.86 minutes per shift by using the automated system to record vital signs. This finding equated to a 63% decrease in time spent in collecting vital signs data, allowing a reduction in 2.2 FTEs, at an annualized savings of $47,000.

Meyer (1992) reported that installation of the MedTake (PC-based) bedside charting system at Ridgewood's Valley Hospital for six months resulted in a savings of 30 minutes per nurse per shift in documentation time and eliminated overtime costs for this activity. The nurses stated that their favorite benefits of the system were the running total for I&O and standardization of forms and terminology.

Hendrickson and Kovner (1990) have written that it is difficult to compare the results of computer benefits studies, because they are purchased and developed for different reasons, with different applications, by different hospitals. Without knowing the type of unit (ICU versus med-surg), the computer platform (PC, UNIX, mainframe, etc.), and characteristics of the environment (acuity, nurse-patient ratios, etc.), it is difficult to translate one hospital's experience with automation to another facility.

Hendrickson and Kovner (1990), Pryor (1989), and Staggers (1988) have all criticized computer benefits studies because often the time lag between pre- and post-study is great enough to allow for other changes to occur that would influence the results. There could be changes in occupancy, acuity, staffing, policies, or any of the myriad influences that could affect the outcome of a benefits study. Pryor (1989) maintains that even the time lag itself can have an affect, as nurses become more familiar and proficient with computer charting and take less time to do it.

Staggers (1988) asserts that enough studies have been done to document the benefits of existing clinical computer systems and that attention should now be turned to developing new systems. Existing systems are almost exclusively designed to support function rather than process and tend to do little more than replace a paper system (Tonges & Lawrenz, 1993).

Ball and Douglas (1988) contend that new technology enters the workplace in three stages. Stage one is replacement: a little faster, a little more efficient. Stage two is innovation: new uses that go beyond the replacement system. Stage three is transformation: complete revolution in the way to do business. Nursing information systems would seem to be mired in stage one, replacement. These authors recommend that future research in the area of nursing automation should be aimed at moving the industry toward stage two, innovation; a shift from methods of data collection to methods of data use.

Summary

There are many requirements for nursing documentation, chief among them the needs to satisfy legal, regulatory, quality improvement, and financial initiatives. These requirements impact the content and structure of nursing documentation and provide the primary inputs to the process of nurse charting. In order to manage data collection and retrieval to meet the growing requirements for nurse charting, nursing administrators have implemented a variety of structured charting methods, and an increasing number have implemented automated documentation systems.

Process improvements have been realized by implementing a manual method of charting that emphasizes the nursing process and adds some measure of standardization, brevity, and structure to the charting process. Specifically, implementation of flowcharts, PIE charting, and charting by exception have proven to save nurses time in data collection and use. Of greater potential is the use of computers to record data at the patient's bedside; a medium that is often cited as producing better documentation in less time.

While there are articles that advance the anecdotal claims that computers save nurses time and increase the quality of their records, there are few empirical studies in the published literature to support these claims. A review of benefits studies reveals that computers have been shown to improve the accuracy, completeness, legibility, timeliness, and accessibility of nursing documentation. Benefits studies have not shown that computers save nurses a significant amount of time in charting nor result in increased time spent with patients.

CHAPTER 3

PROCEDURE FOR COLLECTION AND TREATMENT OF DATA

This retrospective study used meta-analysis, a methodology that enables the systematic review and quantitative integration of results of multiple primary studies that are relevant to a particular research question (Reynolds, Timmerman, Anderson, & Stevenson, 1992). A meta-analysis involves obtaining studies that are appropriate to a particular phenomenon of interest; treating the summary statistics from each study as the units of analysis; aggregating the data in some way; and then analyzing the data with quantitative tests of the hypotheses or research questions under investigation (Duffy, 1988). The results of meta-analytic research usually include an effect size for each study, an average effect size that is calculated across studies, and analysis of the relationship between study outcomes and substantive and methodological characteristics of the studies (Brown, 1990). In meta-analysis, the results or findings of the studies are the dependent variables in the statistical analysis, while the independent variables are the substantive and methodological characteristics of the integrated studies (Glass, McGaw, & Smith, 1981).

In order to feasibly integrate findings of multiple studies, the findings must be expressed on some common scale, and a variety of transformation procedures are available to facilitate this occurrence (Glass, McGaw, & Smith, 1981; Hunter & Schmidt, 1990; Wolf, 1986).

However, "study findings can be expressed directly in cases where a simple statistical expression of results is common to all studies" (Glass, McGaw, & Smith, 1981, p. 93).

Meta-analysis can be performed on both experimental and descriptive studies (Reynolds, Timmerman, Anderson, & Stevenson, 1992) and can be used to integrate as few as two studies (Duffy, 1988; Hunter & Schmidt, 1990). Ideally, a meta-analysis contains both published and unpublished studies, but can be performed on a convenience sample of studies, so long as the sample is representative of the domain of interest to the meta-analyst (Hunter & Schmidt, 1990).

A meta-analysis of work sampling studies conducted pre- and post-implementation of the System 2000 computerized nursing documentation system in intensive care units (ICUs) was conducted for this study. Pre- and post-implementation results of multiple work sampling studies were coded in a meta-analysis codebook. These outcome measures were then combined into four subsets that were treated as the dependent variables for analysis: (1) direct patient care, (2) indirect patient care, (3) communication, and (4) charting. Data were integrated across studies, and the effect of bedside computer charting on nursing time spent in direct patient care, indirect patient care, charting, and communication were reported in terms of percent of change (the metric common to all work sampling studies) and in standardized mean effect sizes (the metric commonly used in meta-analysis).

The methodological characteristics of the studies constitute the independent variables of the meta-analysis and four of these were evaluated to determine their relationship to the effect sizes of the four dependent variables. Prior use of computers, type of computer applications in use at the time of the post-study, length of time between the pre- and post-study, and quality of the primary studies were evaluated to determine their relationship with the effect sizes of the four dependent variables. The independent variable "quality of study" was determined by coding attributes of the quality of each study in a codebook.

Setting

The work sampling studies included in this meta-analysis were conducted in hospital intensive care units in which the System 2000 bedside computer system is installed. The hospitals were located in different states. Their ICUs were of different types and sizes and were configured as wards, private rooms, or a combination of wards and rooms around a central nursing station. Each ICU had previously installed a Unix-type computer workstation at each patient's bedside, and each workstation was interfaced to a cardiac monitor for automatic acquisition of hemodynamic and vital signs data. It was anticipated that the ICU personnel in some of the hospitals may have had prior experience with computers in the form of order entry, results reporting, or other applications that commonly comprise a Hospital Information System (HIS). For others, the System 2000 might have been their first exposure to computer use. Since the System 2000 is user configurable, the applications in use at the time of the post-study may vary.

Population and Sample

In a meta-analysis, the studies selected for integration constitute the sample for analysis. A meta-analysis should ideally be based on a large number of studies that are located through an exhaustive search and contain both published and unpublished research. However, meta-analysis is also valid for convenience samples as long as the sample of studies is representative of the universe of existing studies in the domain of interest to the meta-analyst (Glass, McGaw, & Smith, 1981; Hunter & Schmidt, 1990).

The target population for this study was all hospitals in which the System 2000 bedside computer system is installed and where a work sampling study was conducted pre- and post-implementation to determine the effect of the system on distribution of time that nurses spend in the performance of various nursing activities. The sample for this analysis was studies from those hospitals in the target population who consented to participate in the meta-analysis.

The target population was identified by obtaining from the vendor a list of its installed sites and the name, address, and phone number of a contact person in each institution. The investigator telephoned each contact person to inquire whether the institution conducted a work sampling study pre- and post-implementation of the System 2000 in one or more of their ICUs. In cases where the response from the institution was affirmative, the investigator described the study and inquired whether the institution would consent to participate. Those who agreed were given the investigator's name, address, and phone number and were asked to mail their work sampling data to the investigator, including their codebook, definitions, raw data, and the final report of the study. Upon receipt of the data from the consenting institutions, the investigator reviewed the data for inclusion in the meta-analysis.

To be included in the sample, the hospital must have consented to participate in the meta-analysis and have submitted its data to the investigator, the ICU must have implemented at least the vital signs flowsheet, and the System 2000 must be interfaced to at least the cardiac monitors. The studies from institutions that met these inclusion criteria constituted the sample for this meta-analysis.

Protection of Human Subjects

Agency approval was obtained from each institution whose work sampling study was included in the meta-analysis (see Appendixes A, B, and C). As a meta-analysis uses actual studies as the sampling units, no human subjects were involved in the investigation. Therefore, a full review by the Texas Woman's University Human Subjects Review Committee was not required (see Appendix D).

The authorizing agent from each institution in the sample was informed that the hospital's participation in the meta-analysis was voluntary and it could withdraw from the study at any time. Potential risks and benefits to the institution were outlined for the agent, and he/she was informed that there may or may not be any direct benefits to the hospital by participating in the meta-analysis. Participants were given the name, address, and phone number of the investigator and were told that she would be available to answer questions as needed. The results of the meta-analysis will be made available to the participating institutions upon request. The institution's agent was also told that submission of the hospital's work sampling data to the investigator would constitute its consent to participate in the meta-analysis.

The authorizing agent for each participating hospital was told that, while anonymity cannot be guaranteed, all information will be kept confidential, and the hospital will not be identified in the meta-analysis. A code number was used to identify participating hospitals and only group data is reported. Others who assisted the investigator in coding study data identified each study by its code number and were not informed of the hospital's name.

A Hospital Information Sheet was maintained by the investigator during the study which contained names, addresses, and phone numbers of the contact person(s) in the participating hospitals. This information sheet and all data relative to the meta-analysis was kept in a locked drawer that could be accessed only by the investigator.

Instruments

The instruments developed for a meta-analysis are those used to identify and subsequently code the methodological and substantive characteristics of the primary studies under consideration. Therefore, the coding form, or "codebook", used to extract information from primary studies is the primary research tool for meta-analysis. The codebook developed for a meta-analysis is analogous to an instrument designed to measure the variables in primary research, and validity and reliability in measuring and coding for meta-analysis must be as rigorous as in primary research (McCain, Smith, & Abraham, 1986).

A codebook was developed to serve as the data collection tool for this study. A panel of four critical care nurses, two management engineers, and the investigator established the criteria for and format of the codebook, which is designed to permit coding of observed nursing activities in an intensive care unit. Upon completion of the codebook, it was presented to critical care staff in a large neurosurgical intensive care unit and a cardiology intensive care unit for review. No changes were made to the codebook following this review, as the nurses in the two intensive care units agreed that the nursing activities included in the codebook were representative of the universe of activities undertaken by staff in an intensive care unit, and the categories of activities were appropriate (see Appendix E).

Validity in meta-analysis depends on the meaning of coded or measured characteristics and includes such things as clarity of definitions, degree of inference a coder makes when determining from a written report what characterized the primary research, and adequacy of reported information. Validity in meta-analytic studies can be enhanced by greater care in reading and coding studies, making definitions clearer, and breaking broad concepts into more refined ones (Glass, McGaw, & Smith, 1981).

Interrater reliability testing is the most important consideration in assuring reliability in a meta-analysis, as the studies themselves are stable (Glass, McGaw, & Smith, 1981). The principle source of measurement unreliability in meta-analysis is different coders not judging or coding study characteristics in the same way.

As correct coding of the primary studies is essential to the validity and reliability of a meta-analysis, Hunter and Schmidt (1990) recommend that at least two persons code each primary study, and that interrater reliability be assessed for each study coded. Brown (1990) also recommends that at least two coders code each study, with interrater reliability being assessed and reported as an essential part of the meta-analysis. The current meta-analysis employed this practice, and it was incorporated into a pilot study of the instrument.

Pilot Study

A pilot study was conducted to test the codebook and measure the interrater reliability of the coders in coding primary studies and applying the definitions of (a) direct patient care, (b) indirect patient care, (c) charting, and (d) communication to combine the coded nursing activities into these four subsets. Using the codebook, one work sampling study that meets the criteria for inclusion in the proposed meta-analysis and one work sampling study that does not were coded by the investigator and a second coder, who is a master's prepared management engineer with expertise in work sampling studies. A 94% agreement between the two coders was achieved when their codebooks were compared. Differences in coding were reconciled through discussion, and it was felt that no changes in the codebook were needed. Next, the two coders independently applied the definitions of the subsets to combine the discreet nursing activities recorded in each of the primary work sampling studies into the four subsets of interest. Upon comparison, the two coders had achieved 100% agreement in combining the coded activities into the subsets. Based on the findings of the pilot study, no changes were made to the codebook or the definitions of the subsets.

Data Collection

Upon approval by Texas Woman's University, primary studies that met the inclusion criteria for the proposed meta-analysis were obtained (see Appendix F). The substantive and methodological characteristics of each pre- and post-implementation work sampling study were coded by the investigator and a second coder, the master's prepared management engineer who participated in the pilot study. Hunter and Schmidt (1990) assert that coding of the primary studies can be 90-95% of the work in a research integration process.

A meta-analysis can be used to integrate several studies on a single phenomenon or on several phenomena. When the meta-analyst wishes to measure effects on several phenomena, the primary studies are coded to identify the domains of interests and a separate meta-analysis is performed on each of these subsets prior to integrating effects across studies for the final meta-analysis (Hunter & Schmidt, 1990). A subset approach was undertaken for the current meta-analysis.

Using the codebook, the coders documented the number of observations of each nursing activity recorded in the primary studies pre- and post-implementation of bedside computers, ending with a completed codebook for each study. Upon completion of coding, interrater reliability was assessed and any differences in coding were discussed and reconciled. Next, the two coders used the definitions of direct patient care, indirect patient care, communication, and charting to combine the activities coded in each primary study into four domain subsets, by summing the number of observations of activities that met the definition for each activity domain. Interrater reliability was again assessed and differences were reconciled through discussion.

At the conclusion of the data collection, for each primary study the investigator had observed nursing activities pre- and post-implementation of the bedside computer system, coded and combined into four subsets within the dependent variables of this study: (a) direct patient care, (b) indirect patient care, (c) communication, and (d) charting. These four subsets of nursing activity were integrated across studies in the meta-analysis. The methodological characteristics of the studies were also coded for analysis.

Treatment of Data

Meta-analysis provides a methodology for discovering the latent meaning of existing research. It involves procedures that allow the integration of results from existing studies to reveal patterns of underlying relations and causalities that once known will constitute general principles and cumulative knowledge (Hunter & Schmidt, 1990).

A subset meta-analysis was performed on each of the domain subsets of interest to the meta-analyst, measuring specifically the effect of bedside computer charting on the time nurses spend in: (a) direct patient care, (b) indirect patient care, (c) communication, and (d) charting. Data from each primary study were reported in four summary tables, one for each of the domain subsets. Figure 3 details the column headings in the summary tables and summarizes the statistical treatment of data that was performed on each domain subset.

Figure 3. Format for Subset Meta-analysis Summary Table

Name of Domain Subset

Study ID	X(b)	X(a)	%(b)	%(a)	%(c)	d(w)	95% Confidence . Interval .

Where: Study ID = study code
X(b) = No. of observations in the pre-study
X(a) = No. of observations in the post-study
%(b) = percent of time spent on activity in the pre-study
%(a) = percent of time spent on activity in the post-study
%(c) = percent of change in pre-study to post-study
d(w) = effect size weighted for sample size

Integrated data for the overall meta-analysis was reported in a separate summary table, as detailed in Figure 4. The final meta-analysis integrated the weighted effect sizes for each of the domain subsets, across primary studies.

Following data collection, the meta-analyst had for each primary study, the individual nursing activities documented in the pre- and post-work sampling studies, coded and combined into four domain subsets. These data included the total number of observations of activities in

Figure 4. Format for Meta-analysis Summary Table

Domain Subset	n(b)	n(a)	%(a)	%(b)	%(c)	d(w)	95% Confidence Interval

Where: n(b) = No. of combined observations in the pre-studies
n(a) = No. of combined observations in the post-studies
%(b) = percent of time spent on activity in the pre-study
%(a) = percent of time spent on activity in the post-study
%(c) = percent of change in pre-study to post-study
d(w) = weighted mean effect size (weighted for sample size)

the pre- and post-studies that comprised each subset. Treatment of data began by recalculating the proportion of time that nurses spent in the performance of each of the activity subsets, relative to the total time that they were observed in the pre- and post-work sampling studies. The percent of time spent in each of the activity subsets post-implementation was then subtracted from the percent of time spent in the activity pre-implementation to determine the percent change pre- and post-implementation of the bedside computers.

The percent change was converted to an effect size, denoted by the letter d, through use of probit analysis techniques described by Glass, McGaw, and Smith (1981), and utilized by Brown (1990). In probit analysis, the percent value obtained in the "before" study and the percent value obtained in the "after" study are used to enter a probit transformation table to determine the percent change expressed as an effect size. A positive sign is then assigned to values of d associated with results favoring the post-test condition, while a negative sign is assigned to values of d associated with results favoring the pre-test condition (Brown, 1990; Wolf, 1986). The effect sizes calculated manually by probit transformation were later verified by a computer program written by Johnson (1989) at Syracuse University for calculation of effect sizes from various metrics reported in primary studies integrated in a meta-analysis. The obtained d value, with its positive or negative sign, was reported in a summary table for each domain subset, for each study.

The obtained effect sizes were next corrected for sample size. The most damaging artifact in cumulative reviews is sampling error that occurs when studies to be integrated contain unequal sample sizes (Hedges & Olkin, 1985; Hunter & Schmidt, 1990). To adjust for sample size, each effect size was multiplied by a constant calculated by the formula: $1-[3/(4\{n1 + n2\} - 9)]$ (Hedges & Olkin, 1985, p. 81). The value for n1 was the number of observations included in the domain subset in the pre-study and the n2 value was the number of observations included in the domain subset in the post-study. In work sampling, the sample of the study is observations, not persons being observed (Abdellah & Levine, 1954). The decision to use number of observations as the sample size for calculation of sample weights was discussed by the meta-analyst with Dr. Sharon Brown, an experienced meta-analyst (Brown, 1990), who agreed with this choice.

The weighted effect sizes were used to calculate a 95% confidence interval to determine the distribution of the metric. Confidence intervals were calculated by a computer program that was written to calculate such intervals about an effect size (Johnson, 1989).

For the final meta-analysis, the weighted effect sizes for each domain subset in each primary study were combined to calculate an average effect size for each subset across studies (Hunter & Schmidt, 1990). In summing the effect sizes, the positive or negative signs associated with the d values were entered into the equation (Brown, 1990; Wolf, 1986). The resulting mean effect sizes were used to demonstrate the magnitude of the effect of bedside computers on the proportion of time intensive care nurses spend in the activities: direct patient care, indirect patient care, charting, and communication.

The obtained d values were compared to the Cohen guidelines for interpretation of effect sizes (Brown, 1990; Wolf, 1986). This comparison allowed the meta-analyst to report that the obtained effect size is small, medium, or large, according to the Cohen guidelines.

Finally, Pearson Product-Moment correlational procedures were used to test the relationship between the mean effect sizes for each domain subset and the coded values of the methodological characteristics (a) prior use of computers, (b) type of computer applications in place at the time of the post-study, (c) length of time between the pre- and post-implementation study, and (d) quality of the primary studies. According to Glass, McGaw, and Smith (1981), the study of the relationship between study characteristics and effect sizes can be addressed by any of the many statistical techniques available for study of the association or relationship between two variables, but tests derived from the "Pearson Product-Moment procedures are the most powerful and useful for this purpose" (p. 158). This procedure is also recommended by Brown (1990) and Hunter and Schmidt (1990).

of the correlational procedures were used to assess the relationship between the effects of bedside computers and methodological characteristics of the primary studies.

Summary

A meta-analysis of unpublished work sampling studies that were conducted in hospitals pre- and post-implementation of the System 2000 bedside charting system was conducted to determine the effect of the system on the proportion of time that intensive care nurses spend in (a) direct patient care, (b) indirect patient care, (c) charting, and (d) communication. A codebook was developed and pilot tested by the meta-analyst for the purpose of coding substantive and methodological characteristics of the primary work sampling studies in the sample. Following approval from Texas Woman's University, the meta-analyst and a second coder used the codebook to code activities documented in the primary studies and combine the activities into four subsets, reflective of the domains of interests to this meta-analysis. Interrater reliability testing was assessed with each coding effort and differences were resolved through discussion. A subset meta-analysis was performed on each activity domain resulting in the calculation of an effect size for each subset for each study. For the final meta-analysis, effect sizes, weighted for sample size, were combined to create a weighted mean effect size for each domain subset across studies. The magnitude of the effect of bedside computers was reported using Cohen's guidelines for interpretation. The relationship between weighted mean effect sizes and methodological characteristics of the studies was determined by Pearson Product-Moment correlational procedures.

CHAPTER 4

ANALYSIS OF DATA

The purpose of this study was to integrate, through meta-analysis, the findings of several unpublished work sampling studies to determine the effect of bedside computers on the distribution of time that nurses spend in the performance of certain activities in intensive care units (ICUs). The study also sought to determine the relationship between the effects of bedside computers and methodological characteristics of the primary studies. Chapter 4 will describe the primary studies that were included in the sample, the process and findings of the meta-analysis, and the relationship between relevant methodological characteristics of the sample and findings of the meta-analysis.

Description of Sample

The sample for the meta-analysis consisted of three unpublished work sampling studies that were performed by hospitals in which the System 2000 bedside computer system is installed in an ICU. In each setting the System 2000 is operating on a Unix-type workstation at the patient's bedside and is interfaced to a physiological monitoring system for automatic acquisition of vital signs and hemodynamic data. The sample is described in Table 1. To assure the anonymity of the hospitals, the facilities are identified by a number only.

The three hospitals in the sample are large teaching hospitals located within the continental United States. Hospitals number 1 and 2 have installed the System 2000 in a surgical intensive care unit (SICU), while hospital number 3 has the system installed in a neurosurgical intensive care unit (NICU).

Table 1

Sample for Meta-analysis of Work Sampling Studies Conducted Pre- and Post-implementation of Bedside Computers in ICUs

Hospital ID No.	ICU	Beds	Time Between Pre & Post-Study	Prior Computer Use?	Applications Installed	Study Quality
1	SICU	18	9 mo.	Yes	VS, Monitor interface, I&O, Nurses Notes module, Graphics	2
2	SICU	12	6 mo.	Yes	VS, Monitor interface, I&O, Nurses Notes module, Graphics	2
3	NICU	16	11 mo.	Yes	VS, Monitor interface, I&O, Graphics, Cell Notes	2

The bed capacity of the sample units varied from 12 beds at hospital number 2, to 16 beds at hospital number 3, and 18 beds at hospital number 1. The time between the pre- and post-studies varied from a low of six months for hospital number 2 to a high of 11 months for hospital number 3, with hospital number 1 having nine months between pre- and post-study. Each of the hospitals had previously installed computers in the intensive care unit for order entry and results reporting, and the nurses in hospital number 3 were entering their patient classification data on a computer. Therefore, in no case was the System 2000 the nurses first exposure to computers in the work environment. At the time of the post-study, each hospital had installed the System 2000 vital signs, monitor interface, I&O, and graphics applications for computerized documentation. Hospitals 1 and 2 had installed the nurses notes module, while hospital number 3 was entering notes through data cells. Each of the studies had a quality rating of 2, meaning that each hospital reported having trained its observers in the techniques of work sampling and had allowed practice, but none had performed interrater reliability with observers prior to or during the work sampling studies.

In a meta-analysis, the primary studies constitute the sample and are stable (Glass, McGaw, & Smith, 1981). However, analysis of characteristics of the primary studies can aid in interpreting the findings of the meta-analysis. As work sampling is the research method common to each of the primary studies in this sample, the characteristics of each work sampling study do themselves constitute findings and serve to further describe the sample. Characteristics of the work sampling studies are detailed in Table 2.

Each hospital in the sample utilized the same process for conducting a work sampling study. A committee determined the activity categories to be coded and worked with management engineers to develop a data collection tool. Hospitals 1 and 3 utilized their own management engineers, while hospital number 2 worked with a management engineer

Table 2

Characteristics of the Primary Work Sampling Studies

Study ID	Type of Observer	Length of Study	Freq. of Observ.	Ave. Census Pre-	Ave. Census Post-	Tot. Observ. Pre-	Tot. Observ. Post-
1	Student Nurses	4 days Fri -> Mon	Q 15 min	11	11	1344	1277
2	Student Nurses	7 days Mon -> Sun	Q 10 min	12	12	2420	1911
3	Nurses (RNs)	4 days Mon -> Thu	Q 15 min	13	8	2696	1659
			Total Observations:			6460	4847

from a consulting firm. Hospitals 1 and 2 used nursing students as their observers. Hospital number 3 used registered nurses, who volunteered to participate as observers in order to complete a research component of their levels program. Approximately 50% of the nurses who served as observers in the pre- and post-study at hospital number 3 were ICU nurses who worked in other ICUs in the hospital. Nurses from the ICU being observed were not allowed to participate as observers of their own unit.

All of the hospitals conducted their work sampling studies 24-hours a day over the length of their study. Hospital number 1 conducted its study for four days, including Friday, Saturday, Sunday, and Monday. Hospital number 2 completed work sampling of an entire week, Monday through Sunday. Hospital number 3 conducted its study over four days, Monday through Thursday.

Hospitals 1 and 3 made observations every 15 minutes and hand recorded the frequency of observed activities on a data collection sheet. Hospital number 2 also hand recorded observed activities on a data collection sheet, but did so every 10 minutes. All of the hospitals in the sample used standard techniques, that is, nomograms or other approved methods, to estimate an appropriate sample size of observations and each hospital obtained the required number of observations for a valid sample.

At hospital number 1, the average census on the 18 bed unit was 11 in both the pre- and post-study. At hospital number 2, the 12 bed unit was fully occupied for both the pre- and post-study. The 16 bed unit at hospital number 3 had an average census of 13 during the pre-study and 8 during the post-study.

Hospital number 1 obtained 1344 observations in its pre-study and 1277 observations in its post-study. Hospital number 2 obtained 2420 observations in its pre-study and 1911 in its post-study. Hospital number 3 recorded 2696 observations in its pre-study, compared to 1659 in its post-study. This data collection provided a total across studies of 6460 observations of nursing activities pre-installation of the System 2000 and 4847 observations post-installation. These individual and combined observations were used to assess the effect of bedside computers on nursing activities in the meta-analysis.

Findings

A subset meta-analysis was performed to address the first research question which asked, what is the magnitude of the effect of bedside computers on the proportion of time intensive care nurses spend in: (a) direct patient care, (b) indirect patient care, (c) charting, and (d) communication. Each of these nursing activities was treated as a domain subset, and these subsets were integrated across primary studies in the meta-analysis.

Using the codebook, the meta-analyst and a second coder coded the results of the primary studies before applying the definitions of direct patient care, indirect patient care, charting, and communication to combine activities into the four domain subsets. The categories of activities in each primary study that were combined to create the domains of direct patient care and indirect patient care are presented in Tables 3 and 4 respectively. In each of the primary studies, a category for charting and communication was reported and was taken intact from the primary reports. As noted in Table 4, charting activities are included in the indirect patient care category but will also be reported as an independent finding.

Analysis of these data began by recalculating the proportion of time that nurses spent in the performance of each of the activity subsets relative to the total time that they were observed in the primary pre- and post-studies. The percent of time spent in each of the activities in the post-study was then subtracted from the percent of time spent in the activities in the pre-study to determine the percent change. Percent change was converted to an effect size, d, through probit analysis. A positive sign was assigned to values of d favoring

Table 3

Activities Combined from Primary Work Sampling Studies to Create the Subset Domain for Direct Patient Care

Study ID	Activities Combined from Primary Studies		No. of Observations Pre-study	Post-study
1	Pat. Care Direct		375	408
	Monitor Watch		81	89
	Pat. Travel W/Pat.		9	16
		Total:	465	513
2	W/Pat./Family		853	807
	Medications		42	45
	Cardiac Monitor		33	9
	Pat. Transf.		33	17
		Total:	961	878
3	Assessments		220	185
	ADL		290	148
	Meds/IVs		338	131
	Procedures		231	125
		Total:	1079	589

the post-test condition and a negative sign was assigned to values of d favoring the pre-test condition. The obtained effect sizes were finally weighted for sample size, and a 95% confidence interval for each weighted effect size was calculated. The final results of the domain subset analysis are detailed in Table 5.

The percent change in the time that nurses spent in indirect patient care and communication activities pre- versus post-implementation of the bedside computers was so low as to yield a weighted effect size at or near zero in the primary studies. Glass, McGaw, and Smith (1981), state that an effect size of less than .1 is

Table 4

Activities Combined from Primary Work Sampling Studies to Create the Subset Domain for Indirect Patient Care

Study ID	Activities Combined from Primary Studies	No. of Observations Pre-study	No. of Observations Post-study
1	Paperwork	229	157
	Computer use	12	87
	Report	99	69
	Supplies	65	53
	Pat. care: Indirect	23	18
	Checking equip.	10	11
		438	395
2	Charting Manual	357	198
	Charting Computer	49	190
	Report	228	206
	Linen/Util. Room	19	18
	Equipment	23	24
	Supplies	53	12
	Dietary	4	1
	Errands	57	22
	Phone calls	66	54
	Standby/Waiting	97	57
		953	782
3	Documentation	379	236
	Other Indirect Care	813	544
		1192	780
	Total:	2583	1957

essentially no effect. The impact of computers on direct patient care and charting activities was found to be small when their weighted effect sizes were compared to Cohen's guidelines for interpreting effect sizes: 0.2 = small effect; 0.5 = medium effect; and 0.8 = large effect (Brown, 1990, p. 190).

For the overall meta-analysis, the weighted effect sizes for each

Table 5

Domain Subset Analysis of the Impact of Bedside Computers on the Time ICU Nurses Spend in Various Nursing Activities

Subset: Direct Patient Care — Average %(c): 2.1%

Study ID	n(b)	n(a)	%(b)	%(a)	%(c)	d(w)	95% Confidence Interval
1	465	513	34.6%	40.2%	5.6%	.12	-.01 to +.24
2	961	878	39.7%	45.9%	6.2%	.13	+.03 to +.22
3	1079	589	40.0%	35.5%	-4.5%	-.10	-.19 to +.01

Subset: Indirect Patient Care — Average %(c): .4%

Study ID	n(b)	n(a)	%(b)	%(a)	%(c)	d(w)	95% Confidence Interval
1	438	395	32.6%	30.9%	-1.7%	.04	-.17 to +.10
2	953	782	39.4%	40.9%	1.5%	-.03	-.06 to +.13
3	1192	780	44.2%	47.0%	2.8%	-.06	-.03 to +.15

Subset: Charting — Average %(c): -2.7%

Study ID	n(b)	n(a)	%(b)	%(a)	%(c)	d(w)	95% Confidence Interval
1	229	157	17.0%	12.3%	-4.7%	.13	-.33 to +.07
2	357	198	14.8%	10.4%	-4.4%	.13	-.30 to +.04
3	379	236	14.1%	14.2%	0.1%	0	-.16 to +.17

Subset: Communication — Average %(c): - .1%

Study ID	n(b)	n(a)	%(b)	%(a)	%(c)	d(w)	95% Confidence Interval
1	178	170	13.2%	13.3%	0.1%	0	-.21 to +.21
2	66	54	2.7%	2.8%	0.1%	-.01	-.36 to +.37
3	133	64	4.9%	3.9%	-1.0%	.05	-.35 to +.25

Where:
- Study ID = hospital ID number
- n(b) = No. of observations in the pre-study
- n(a) = No. of observations in the post-study
- %(b) = percent of time spent on activity in the pre-study
- %(a) = percent of time spent on activity in the post-study
- %(c) = percent of change in pre-study to post-study
- d(w) = effect size weighted for sample size

domain subset in each primary study were combined to calculate an average effect size for each subset across studies. In summing the effect sizes, the positive or negative sign associated with the d values was entered into the equation. The resulting weighted mean effect sizes describe the magnitude of the effect of bedside computers on the time intensive care nurses spent in the activities: direct patient care, indirect patient care, charting, and communication. Findings are detailed in Table 6.

Table 6

Weighted Mean Effect Sizes for the Impact of Bedside Computers on the Time that ICU Nurses Spend in Various Activities

Domain Subset	n(b)	n(a)	%(a)	%(b)	%(c)	$\bar{d}$(w)	95% Confidence Interval
Direct Pt. Care	2505	1980	38.8%	40.9%	2.1%	.05	-0.02 to +0.11
Indirect Pt. Care	2583	1957	40.0%	40.4%	.4%	.01	-0.05 to +0.07
Charting	965	591	14.9%	12.2%	-2.7%	.08	-0.18 to +0.24
Communication	377	288	5.8%	5.9%	.1%	0	-0.15 to +0.16

Where: n(b) = No. of combined observations in the pre-studies
n(a) = No. of combined observations in the post-studies
%(b) = percent of time spent on activity in the pre-study
%(a) = percent of time spent on activity in the post-study
%(c) = percent of change in pre-study to post-study
$\bar{d}$(w) = weighted mean effect size (weighted for sample size)

As reflected in Table 6, the weighted mean effect of computer installation on the time that nurses spent in direct patient care (.05) and charting (.08) activities, even in a combined sample, was less than small when compared to Cohen's guidelines for interpreting effect sizes: 0.2 = small effect; 0.5 = medium effect; and 0.8 = large effect size. The weighted mean effect sizes for bedside computer installation on the time nurses spent in indirect patient care (.01) and communication (0) activities were so low as to be considered no effect at all.

The second research question of this study asked if there is a relationship between the effects of bedside computers and the methodological study characteristics: (a) prior use of computers, (b) type of computer applications in use at the time of the post-study, (c) length of time between the pre- and post-implementation work sampling study, and (d) quality of the primary studies. The intent was to identify moderator variables which might have influenced the obtained effect sizes. Correlational analyses were conducted to determine relationships between weighted effect sizes obtained in the subset analysis and relevant methodological characteristics of the primary studies.

The subset analysis, as detailed in Table 5, yielded marginal weighted effect sizes for the domain subsets of direct patient care and charting and were selected for further analysis to determine their relationship to methodological characteristics of the studies. The effect sizes for the subsets indirect patient care and communication were found to be less than .1 or essentially no effect and they were eliminated from consideration for further statistical analysis.

After coding the methodological characteristics of the primary studies, there proved to be remarkably little variation in the characteristics across the studies in the sample. All of the hospitals had previously installed computers in the ICUs for order entry, results reporting, and other applications prior to installation of the bedside computers. Each of the hospitals had achieved a quality rating of 2, and each had installed essentially the same number and type of applications at the time of the post-study. Only the length of time between the pre- and post-implementation work sampling study varied across studies, making this the only methodological characteristic suitable for further statistical analysis to determine its possible relationship to the weighted effect sizes obtained in the subset analysis.

A Pearson Product-Moment correlational analysis was conducted to determine the relationship between length of time between the pre- and post-implementation work sampling studies and the weighted effect sizes for direct patient care and charting. No significant relationship was found between length of time between the pre- and post-study and the weighted effect sizes for direct patient care ($r = -.12$) or the weighted effect sizes for charting ($r = .02$).

Summary of Findings

A subset meta-analysis was conducted to determine the effect of bedside computers on the amount of time ICU nurses spend in direct patient care, indirect patient care, charting, and communication activities. Installation of the bedside computer system was found to have no real effect on the time that ICU nurses spent in direct patient care (.05), indirect patient care (.01), charting (.08), and communication (0) activities when compared to Cohen's guidelines for interpreting effect sizes: 0.2 = small effect; 0.5 = medium effect; and 0.8 = large effect size. There was an average increase of 2.1% of nursing time spent in direct patient care activities after installation of the bedside computers, and an average decrease of 2.7% in nursing time spent in charting activities post bedside computer installation.

The methodological characteristics considered in this study as possible moderator variables which might have influenced effect sizes were (a) prior use of computers, (b) type of computer applications in use at the time of the post-study, (c) length of time between the pre- and post-implementation work sampling study, and (d) quality of the primary studies. After coding the primary studies, only length of time between the pre- and post-implementation work sampling study was found to vary across studies.

A Pearson Product-Moment correlational analysis was conducted to determine if there is a relationship between length of time between the pre- and post-studies and the weighted effect sizes for direct patient care and charting activities. No significant relationship was found between length of time between the pre- and post-study and the weighted effect sizes for direct patient care ($r = -.12$) or charting ($r = .02$).

CHAPTER 5

SUMMARY OF THE STUDY

The purpose of this study was to integrate the findings of unpublished work sampling studies to determine (1) the effect of bedside computers on the distribution of time nurses spend in the performance of certain activities in an intensive care unit and (2) the relationship between the effects of bedside computers and methodological characteristics of the primary studies. The process of integration was meta-analysis.

Summary

A meta-analysis of unpublished work sampling studies that were conducted in hospitals pre- and post-implementation of the System 2000 computerized bedside charting system was conducted to determine the effect of the system on the proportion of time that intensive care nurses spend in (a) direct patient care, (b) indirect patient care, (c) charting, and (d) communication. A codebook was developed and pilot tested by the meta-analyst for the purpose of coding substantive and methodological characteristics of the primary studies. Following approval from Texas Woman's University, the meta-analyst and a second coder coded activities documented in the primary studies, and then applied to the coded data the definitions of direct patient care, indirect patient care, charting, and communication to combine the activities into four domain subsets for further analysis.

A subset analysis was performed on each domain subset resulting in the calculation of an effect size for each subset for each study. As percent is the metric common to all work sampling studies, the percent change in the amount of time that the nurses spent in each activity domain pre- to post-study had to be changed to an effect size, d, the metric most common to meta-analysis. The calculation of effect size from a percent was accomplished through probit transformation techniques first done manually and then verified by computer analysis. The obtained effect sizes were weighted for sample size, and their distribution was further described by calculating and presenting a 95% confidence interval about the weighted effect size for each domain subset for each study. For the meta-analysis, the weighted effect sizes were combined to create a weighted mean effect size for each domain subset across studies. The magnitude of the effect of bedside computers was assessed and reported using Cohen's guidelines for interpretation.

To determine the relationship between the effects of bedside computers and methodological characteristics of the primary studies, each primary study was coded to reflect (a) prior use of computers, (b) type of computer applications in use at the time of the post-study, (c) length of time between the pre- and post-study, and (d) quality of the primary study. Pearson Product-Moment correlational procedures were used to test the relationship between the effect sizes for selected domains in the subset analysis and relevant methodological characteristics of the studies.

Discussion of Findings

Analysis of data to assess the magnitude of the effect of bedside computer installation on the allocation of nursing time among activities in an ICU revealed that installation of the System 2000 resulted in a small increase in the proportion of time that nurses spent in direct patient care activities and a small decrease in the proportion of time that they spent in charting activities. Computerized charting had virtually no affect on the proportion of time that nurses spent in indirect patient care and communication activities. Data relative to the effects of computer installation on direct patient care and charting activities were further assessed to determine their relationship to length of time between the pre- and post-study, the only methodological characteristics coded in the studies that varied across studies. Using Pearson Product-Moment correlation procedures, no significant relationships between these variables were found.

The findings of the meta-analysis are consistent with, although less dramatic than, those found at Lutheran Hospital, LaCrosse, Wisconsin, site of the one published work sampling study to be performed pre- and post-installation of bedside computer documentation, and the one direct comparison to the present study (Allen & Davis, 1991). Allen and Davis (1991) reported a reduction of 21% in observed charting activities, as compared to a 2.7% reduction realized in the current study. Likewise, the percent increase in the proportion of time spent in direct patient care was greater at Lutheran Hospital (8.5%) than in the current integrative review (2.1%).

There was virtually no change in the amount of time that nurses spent in communication activities pre- versus post-implementation of computers at Lutheran Hospital, a finding consistent with the meta-analysis. Lutheran Hospital did see a slight reduction in the amount of time spent in indirect patient care activities (7.8%), where the integrated sample in the meta-analysis realized an average gain of .4% in this domain.

The small effect that bedside computer charting had on the distribution of nursing time in this meta-analysis can perhaps be explained by reviewing relevant characteristics of the sample itself against prior research findings. Each of the hospitals in this sample had previously installed a hospital information system, with automation of order entry, results reporting, and other functions that are used by nurses for intra and interdepartmental communication. Hendrickson and Kovner (1990), in reporting the results of six computer benefits studies, found that in four of the six studies, time savings in communication was directly attributable to the order entry and results reporting systems. No time savings in communications, nor increases in the amount of communication, could be attributed to automated charting or physiological monitoring systems. Similarly, Peat Marwick Main and Company (1988) found that hospitals that have installed automated information systems at the nursing station may have already realized a significant improvement in productivity and will see less improvement with installation of a bedside system than would be seen in a hospital where no prior automation existed. Peat Marwick Main (1988) concluded that in hospitals where some automation existed at the nursing station prior to installation of a bedside system, productivity gains represent incremental improvements resulting simply from migration of computers to the bedside.

The hospitals in the meta-analysis installed the System 2000 as a bedside system. Halford, Burkes, and Pryor (1989) published a work sampling study which measured, not the impact of computers on nursing service pre- and post-implementation, but rather the impact of migrating an existing computer system from a pod configuration of one computer per four beds in a ward to a bedside configuration. They found that simply moving a system, even the same system, to the bedside resulted in a slight increase in productivity on the nursing unit. Mowry and Korpman (1987) maintain that since 50% of patient data are collected at the bedside, traditionally on scraps of paper, a simple change of medium for documenting these data may have less to do with the medium than with the proximity of the medium to point of service.

The research of Miller and Pastorino (1990) and Welsch and Nicholson (1991) suggest that migration from an efficient manual documentation system may also affect the gains to be seen after implementation of a bedside computer system. Each of the hospitals in this meta-analysis had previously implemented some form of process improvement in their manual charting methods prior to installation of the bedside computers. All of the hospitals had previously charted vital signs, I&O, and other routine data in the ICU on a standardized flowsheet. Additionally, two of the hospitals had adopted a policy of charting by exception, while the third was using the PIE method of charting. As the System 2000 is user configurable, all of the hospitals in the meta-analysis chose to simply automate their existing forms and process of manual charting.

Miller and Pastorino (1990) found that there can be as much as a 40-50% time savings in charting with adoption of a standardized flowsheet. Fracassi (1987) and Smith, LaFoy, Macklin, and Minors (1991) also found significant productivity improvements with implementation of a flowsheet, because it facilitates standardized formats and abbreviated entries. Welsch and Nicholson (1991) reported dramatic time savings with adoption of charting by exception at Marquette General Hospital in Michigan, where they realized a savings of 23% on the day shift, 24% on the evening shift, and 35% on the night shift. At St. Luke's Medical Center in Milwaukee, Wisconsin, they measured a 44% savings in charting time after implementation of charting by exception (Kerr, 1992). Kerr (1992) also reported process improvements in hospitals that have implemented the PIE charting method, because of its emphasis on assessment forms, checklists, and flowsheets. The PIE method of charting can improve productivity, because it streamlines charting and does not require a care plan (Siegrist, Dettor, & Stocks, 1985). In summary, significant gains in productivity can be attained by adopting an efficient method of manual charting.

Prior adoption of improved methods of manual charting, coupled with the fact that each of the hospitals in the sample simply automated their existing forms and formats, may have influenced the degree to which implementation of bedside charting affected the amount of time spent in charting activities in this sample. According to prior research, the ICUs may have already realized a significant time savings in their documentation process by adopting a more efficient means of charting (Welsch & Nicholson, 1991). One can only speculate what the impact of implementing the System 2000 would be on a unit that was migrating from a manual narrative system of charting to a computer based system of flowsheets and charting by exception or PIE charting.

Another characteristic of the sample to be considered in light of the literature review is the length of time between the pre- and post-work sampling study. In classic engineering terms, a post work sampling study should be done within three months of the pre-study (Abdellah & Levine, 1954). In this sample, the hospitals conducted their post-study at six, nine, and eleven months. Both Pryor (1989) and Staggers (1988) have criticized computer benefits studies because often the time lag between pre- and post-study is great enough to allow for other changes to occur that would influence the results. There could be changes in occupancy, acuity, staffing, policies, or any of the myriad influences that could affect the outcome of a benefits study. Pryor (1989) maintains that even the time lag itself can have an affect. He asserts that as nurses become more familiar and proficient with computer charting, they take less time to do it. Although it was found that there was no significant relationship in length of time between pre- and post-study and weighted effect sizes for charting activity in the meta-analysis, it is interesting to note in light of Pryor's assertions that hospital number 3 conducted its post-study at 11 months and had the least percent change (.1%) in charting pre- to post-study. Hospital number 1 conducted its post-study at 9 months and had a percent change in charting activity of -4.7%. Hospital number 2 conducted its post-study at 6 months and had a percent change in charting activity of -4.4%. In other words, the longer the time lag in the post-study, the less change was observed in percent of time spent in charting activities pre- to post-study in this sample. Since the hospitals in the sample did not include in their data a description of changes in their environments that may have influenced charting behavior, no direct conclusions can be made about this finding other than to note it.

Discussion of the findings of this meta-analysis would not be complete without a review of the work sampling methodology employed by the participating facilities. The type of observers used, the failure to assess inter- and intrarater reliability, and the choice of days to perform the work sampling could have impacted the results found in this analysis.

Hospitals 1 and 2 used nursing students as the observers for their work sampling studies, where hospital number 3 used registered nurses, 50% of whom were ICU nurses in both the pre- and post-studies. As can be seen in Table 2, hospital number 3 recorded 2696 observations during its four day pre-study and 1659 observations during its four day post-study. This finding is in contrast to the 2420 observations recorded over seven days in the pre-study at hospital number 2 and 1911 observations recorded over a like seven days in their post-study. The number of observations was also lower at hospital number 1 as compared to hospital number 3.

Sittig (1993) states that an essential element in a work sampling study is the selection of appropriate observers. He cautions that one must question whether the person truly understands the job being observed. Williams (1983) also writes that few activities in nursing are discreet and without knowing the purpose of an activity, it is easy to place the activity in the wrong category or miss it entirely. Perhaps by using registered nurses, particularly ICU nurses, hospital number 3 was able to record more observations because the more experienced observers recognized activities that may have been overlooked or miscoded by students.

A related characteristic of the primary work samplings is that none of the hospitals documented inter- or intrarater reliability testing in its final report. Sittig (1993) maintains that one should plot each observer's totals along with the overall figures daily. One would anticipate that if all observers were equally adept and/or conscientious at classifying activities, all of the individual observer's data points would fall within three standard deviations of the mean. If this finding is not the case, one should investigate the outlier observer to determine the problem. This investigation was not done in any of the studies but would have been helpful in determining if student observers were as consistently proficient at work sampling as registered nurses.

Finally, only one of the hospitals, number 2, conducted its work sampling studies over an entire week. Hospital number 1 sampled over four days, including Friday, Saturday, Sunday, and Monday. Hospital number 3 also sampled four days, but included Monday through Thursday. Sittig (1993) states that a work sampling study should be based on some naturally occuring cycle within the work pattern, for example a week. Further, it is very important to include an equal number of subcycles, such as day versus night, or weekdays versus weekends. As hospital number 3 violated this basic principle of work sampling by sampling only weekdays, one can only guess how this time frame might have affected the assumption of representativeness that underscores a work sampling study. On the other hand, the inclusion of Monday, Tuesday, Wednesday, and Thursday in a work sampling of a neurosurgical intensive care unit, with no inclusion of weekend days, may provide additional insight into the greater number of observations recorded at hospital number 3, since these days are traditionally busy days in a surgical unit. Hospital number 1 had the least amount of observations during its four day work sampling, which may be explained by its inclusion of Friday, Saturday, and Sunday in its sample, days that tend to have less activity in a surgical intensive care unit.

Conclusion and Implications

The findings of the meta-analysis do not support the anecdotal claims of vendors and others who write that computers can reduce time spent in indirect care activities, allowing nurses to spend more time in direct patient care (Casassa, 1990; Meyer, 1992; Mowry & Korpman, 1987; Raygor, 1994; Sinclair, 1991). The installation of bedside computers had virtually no effect on the proportion of time that nurses spent in the performance of activities in an intensive care unit.

Simply replacing a paper charting system with an automated version of the same system does not lead to significant process improvements over the manual process of charting. The implication is that hospitals cannot justify the acquisition of an automated bedside charting system based solely on a belief that the introduction of computers alone can save nurses time in indirect patient care, charting, and communication, or significantly increase the time spent in direct patient care. This justification implies that in order to achieve process improvements with an automated charting system, nurses must go beyond merely replacing their paper method of collecting data and find innovative ways to manipulate and use data through automation, a medium whose potential goes beyond the practical capabilities of a paper chart.

Recommendations for Further Study

The lack of impact that the bedside computer system had on nursing practice in this sample may plausibly be explained by the fact that each of the sample units had prior experience with sophisticated computer technology, and each had previously implemented process improvements in their manual charting methods, which they simply automated. Therefore, one recommendation for further study would be to conduct a work sampling study pre- and post-implementation of a bedside computer system in an intensive care unit that has not had previous exposure to automation and/or will not be automating their existing forms.

A second recommendation for further study would be to repeat the work sampling study in the sample units, since each has now implemented or will soon implement automated care plans and medication administration records (MAR). In each hospital, the automated version of their care plans and MARs is significantly different than the paper-based version it replaces.

A final recommendation for further study would be to assess how nurses can use data and technology, rather than how nurses can collect data with technology. There needs to be a thorough assessment of nursings' needs for data sets and data abstraction, against a thorough understanding of the available technology to accomplish it. Until we move beyond simply replacing a paper system with an automated version of the same system, nursing will not realize the full benefit of automation.

References

Abdellah, F. G., & Levine, E. (1954). Work-sampling applied to the study of nursing personnel. Nursing Research, 3(1), 11-16.

Albarado, R. S., McCall, V., & Thrane, J. M. (1990). Computerized nursing documentation. Nursing Management, 21(7), 64-65.

Allen, D., & Davis, M. (1991). Clinical Information Systems Impact on the Intensive Care Unit: Lutheran Hospital - LaCrosse, Wisconsin. Unpublished manuscript.

American Organization of Nurse Executives. (1992). Nursing management and JCAHO. Nursing Management, 23(5), 26-27.

Ball, M. J., & Douglas, J. V. (1988). Integrating nursing and informatics. In M. J. Ball, K. J. Hannah, U. G. Jelger, & H. Peterson (Eds.), Nursing Informatics: When Caring and Technology Meet (pp. 11-17). New York: Springer-Verlag.

Ball, M. J., & Hannah, K. J. (1984). Using Computers in Nursing. Reston, VA: Reston.

Brown, S. A. (1990). Studies of educational interventions and outcomes in diabetic adults: A meta-analysis revisited. Patient Education and Counseling, 16(3), 189-215.

Casassa, E. (1990, May). Bedside computing positively impacts patient care. Computers in Healthcare, 26-27, 30, 35.

Claflin, N. (1991). Monitoring and evaluation in the special care unit: The JCAHO ten-step process. AACN, 2(1), 12.

Clinton, H. R. (1993). Nurses in the front lines. Nursing and Health Care, 14(6), 286-288

Curlette, W. L., & Cannella, K. S. (1985). Going beyond the narrative summarization of research findings: The meta-analysis approach. Research in Nursing and Health, 8(3), 293-301.

Dennis, K. E., Sweeney, P. M., MacDonald, L.P., & Morse, N. A. (1993). Point of care technology: Impact on people and paperwork. Nursing Economics, 11(4), 229-248.

Dick, R., & Dalton, T. (1994). Outcomes-based management and total quality management. In Guidelines to Effective Health Care Information and Management Systems and the Role of the Chief Information Officer. Chicago, IL: Healthcare Information and Management Systems Society.

Duffy, M. E. (1988). Meta-analysis: A quantitative approach to synthesizing research findings across studies. Nursing and Health Care, 9(6), 287-389.

Dunbar, C. (1991, Oct.). An eye single to the patient. Computers in Healthcare, 30-32.

Edelstein, J. (1990). A study of nursing documentation. Nursing Management, 21(11), 40-43, 46, 49.

Erb, P. S., & Coble, D. (1989, March). Vital signs measured with nursing system. Computers in Healthcare, 32-34.

Fischbach, F. T. (1991). Documenting care: Communication, the nursing process and documentation standards. Philadelphia: F. A. Davis.

Fracassi, J. (1987). ICU Flowsheets: Are they cost effective? Nursing Management, 18(12), 66-67.

Glass, G. V., McGaw, B., & Smith, M. L. (1981). Meta-analysis: In social research. Newbury Park, CA: Sage.

Gwozdz, D. T., & Togno-Armanasco, V. D. (1992). Streamlining patient care documentation. Journal of Nursing Administration, 22(5), 35-39.

Halford, G., Burkes, M., & Pryor, T. A. (1989). Measuring the impact of bedside terminals. Nursing Management, 20(7), 41-45.

Hazzard, M. E. (1971). An overview of systems theory. Nursing Clinics of North America, 6(3), 385-393.

Hedges, L. V., & Olkin, I. (1985). Statistical methods for meta-analysis. Boston: Academic Press.

Hendrickson, G., & Kovner, C. T. (1990). Effects of computers on nursing resource use: Do computers save nurses time? Computers in Nursing, 8(1), 16-22.

Huffman, E. K. (1981). Medical Record Management. Berwyn, IL: Physicians' Record.

Hunter, J. E., & Schmidt, F. L. (1990). Methods of meta-analysis. Newbury Park, CA: Sage.

Johnson, B. T. (1989). DSTAT: Software for the meta-analytic review of research literatures. Hillsdale, NJ: Lawrence Erlbaum.

Joint Commission on Accreditation of Healthcare Organizations. (1990). Primer on indicator development and application. Oakbrook Terrace, IL: Author.

Joint Commission on Accreditation of Healthcare Organizations. (1994). 1994 Accreditation Manual for Hospitals. Oakbrook Terrace, IL: Author.

Kahl, K., Ivancin, L., & Fuhrmann, M. (1991). Identifying the savings potential of bedside terminals. Nursing Economics, 9(6), 391-400.

Kerr, S. D. (1992). A comparison of four nursing documentation systems. Journal of Nursing Staff Development, 8(1), 26-31.

Krum, G. A. (1991). Implementation of structure and process standards. AACN, 2(1), 31-39.

Lower, M. S. & Nauert, L. B. (1992). Charting: The impact of bedside computers. Nursing Management, 23(7), 40-42, 44.

Macklin, D. C. (1990). The evolution of standards: From capability of performance to demonstrated performance. Journal of Intravenous Nursing, 13(4), 249-252.

Mahrenholz, D. M. (1992). Nursing and JCAHO. Nursing Connections, 5(3), 48-52.

Martin, G. T., & Baker, G. (1993). Measuring the benefits of bedside computers. Healthcare Informatics, 10(5), 26, 28, 30.

McCain, N. L., Smith, M. C., & Abraham, I. L. (1986). Meta-analysis of nursing interventions: The codebook as a research instrument. Western Journal of Nursing Research, 8(2), 155-167.

Meyer, C. (1992). Bedside computer charting: Inching toward tomorrow. American Journal of Nursing, 92(4), 38-42, 44.

Miller, P., & Pastorino, C. (1990). Daily nursing documentation can be quick and thorough. Nursing Management, 21(11), 47-49.

Minard, B., Girotto, R. G., Andrews, R., & Salyer, P. (1994). Reengineering and improving the information-intensive work of patient tracking for inpatients and outpatients. Topics in Health Information Management, 14(3), 1-6.

Moreland, J. (1991). Quality assurance to quality improvement: The impact of the Agenda for Change. AACN, 2(1), 82-89.

Mowry, M. M., & Korpman, R. A. (1987). Evaluating automated information systems. Nursing Economics, 5(1), 7-12.

Murphy, J., Beglinger, J. E., & Johnson, B. (1988). Charting by exception: Meeting the challenge of cost containment. Nursing Management, 19(2), 56-58, 62, 64, 68-71.

Murphy, J., & Burke, L. J. (1990). Charting by exception: A more efficient way to document. Nursing, 20(5), 65, 68-69.

Nightingale, F. (1860). Notes on nursing. New York: Appleton.

Patterson, C. H. (1990). Quality assurance, control, and monitoring: The future role of information technology from the Joint Commission's perspective. Computers in Nursing, 8(3), 105-110.

Peat Marwick Main and Company. (1988). TDS Healthcare Systems Corporation bedside terminal study. Unpublished manuscript.

Pierce, L. M. (1972). Usefulness of a systems approach for problem conceptualization and investigation. Nursing Research, 21(5), 509-513.

Pryor, T. A. (1989). Computerized nurse charting. International Journal of Clinical Monitoring and Computing, 6, 173-179.

Putt, A. M. (1978). General systems theory applied to nursing. Boston: Little, Brown.

Raygor, A. J. (1994). A study of the paper chart and its potential for computerization. Computers in Nursing, 12(1), 23-28.

Reynolds, N. R., Timmerman, G., Anderson, J., & Stevenson, J. S. (1992). Meta-analysis for descriptive research. Research in Nursing and Health, 15, 467-475.

Rockwell, D. A., Pelletier, L. R., & Donnelly, W. (1993). The cost of accreditation: One hospital's experience. Hospital and Community Psychiatry, 44(2), 151-155.

Schoessler, M. (1991). Preparing documentation for a JCAHO visit. Journal of Nursing Staff Development, 7(5), 215-219.

Shalala, D. E. (1993). Nursing and Society: The unfinished agenda for the 21st century. Nursing and Health Care, 14(6), 289-291.

Sherer, J. L. (1993, August 20). Next steps for nursing. Hospitals, 26-28.

Siegrist, L. M., Dettor, R. E., & Stocks, B. (1985). The PIE system: Complete planning and documentation of nursing care. Quality Review Bulletin, 11(5), 186-189.

Simpson, R. L. (1992). What nursing leaders are saying about technology. Nursing Management, 23(7), 28-29.

Simpson, R. L. (1994). The role of technology in a managed care environment, Nursing Management, 25(2), 26, 28.

Sinclair, V. G. (1991). The impact of information systems on nursing performance and productivity. Journal of Nursing Administration, 21(2), 46-51.

Sittig, D. F. (1993). Work-sampling: A statistical approach to evaluation of the effect of computers on work patterns in healthcare. Methods of Information in Medicine, 32, 167-174.

Smith, N. W., LaFoy, L., Macklin, D., & Minors, P. (1991). Flow sheets: Does revision improve charting behavior? Nursing Management, 22(6), 40-42, 44-45.

Sovie, M. D. (1989). Clinical nursing practices and patient outcomes: Evaluation, evolution, and revolution. Nursing Economics, 7(2), 79-85.

Staggers, N. (1988). Using computers in nursing: Documented benefits and needed studies. Computers in Nursing, 6(4), 164-170.

Study Group on Nursing Information Systems. (1983). Computerized nursing information systems: An urgent need. Research in Nursing and Health, 6(3), 101-105.

Tonges, M. C., & Lawrenz, E. (1993). Reengineering: The work redesign-technology link. Journal of Nursing Administration, 23(10), 15-22.

von Bertalanffy, L. (1968). General systems theory. New York: George Braziller.

Welsch, E., & Nicholson, S. (1991). Bedside terminals: Panacea or gadget? Nursing Economics, 9(6), 437-440.

Williams, M. A. (1983). Quantification of direct nursing care activities. In R. L. Hanson (Ed.), Management Systems for Nursing Service Staffing (pp. 65-67). Rockville, MD: Aspen.

Wolf, F. M. (1986). Meta-analysis: Quantitative methods for research synthesis. Newbury Park, CA: Sage.

Zielstorff, R. D., McHugh, M. L., & Clinton, J. (1988). Computer design criteria: For systems that support the nursing process. Kansas City, MO: American Nurses Association.

APPENDICES

APPENDIX A

Institutional Approval for Hospital Number 1

[redacted]

September 17, 1993

Ms. Pam Salyer
[redacted]

Ms. Salyer,

Per our conversation, I have attached the work sampling study that the [redacted], Department of Surgery, completed in evaluating the [redacted] clinical information system. This letter confirms our agreement to include this data in your analysis of the impact of clinical information systems. The name of [redacted] may not be included in your analysis and presentation of the data in publications, presentations and such without written permission from the [redacted].

As agreed, you will provide us with the analysis of your data once you have completed your study. Please forward your information to:

[redacted]

If I may be of any further assistance, please feel free to contact me at [redacted]. I wish you success in your study and look forward to your findings.

Sincerely,

[redacted]

[redacted]

APPENDIX B

Institutional Approval for Hospital Number 2

[redacted]

[redacted]

[redacted]

April 22, 1994

Pamela Salyer
[redacted]

Dear Pam:

As we discussed, you may include in your meta-analysis the work sampling study completed by [redacted] to assess the impact of the [redacted]. Per our agreement, you may not include the name of [redacted] in your written report, presentations, or publications without written permission from [redacted]. When you have completed your study, a copy of the meta-analysis will be sent to me.

Enclosed is the work sampling data you requested. If I may be of further assistance, do not hesitate to call me at [redacted] Good luck with your dissertation.

Sincerely,

[redacted]

[redacted]
PCIS Clinical Coordinator

S/d

Enclosures

APPENDIX C

Institutional Approval for Hospital Number 3

[redacted]

March 11, 1994

Pamela Salyer, M.S., R.N.
[redacted]

Dear Pamela:

Attached is the raw data, data collection forms, and Final Report for the work sampling study conducted at [redacted] as part of our benefits analysis of the [redacted]. You hereby have permission to include the data in your dissertation. As we agreed in prior conversation, you may not identify [redacted] in your paper or use its data for any purpose other than your acedemic research without first obtaining written approval from [redacted].

I look forward to receiving a copy of your final work. Please call me if you have questions or need additional information.

Sincerely,

[redacted]

APPENDIX D

Exemption from Human Subject's Review Committee

TEXAS WOMAN'S UNIVERSITY
DENTON DALLAS HOUSTON

HUMAN SUBJECTS REVIEW COMMITTEE - HOUSTON CENTER

EXEMPT FROM HSRC REVIEW

If it is the decision of the research committee (for student research) or the department coordinator (for faculty research) that the proposed research is exempt from expedited or full review by the Human Subjects Review Committee (HSRC), please complete the following form. <u>A copy of this properly signed form must be submitted to the chairman of the HSRC.</u>

Principal investigator: Pamela D. Salyer, M.S., R.N.

Social Security Number: 460-02-1613

Title of the Research: A Meta-analysis of Work Sampling Studies Pre- and Post-Implementation of Bedside Computer Charting in an Intensive Care Unit

1. Give a brief description of the study (use continuation pages or attachments, if necessary). Describe the procedure that relates to the subjects' participation, i.e., what will the subjects do or what will be done to them.

A retrospective meta-analysis of work sampling studies conducted in hospitals pre- and post-implementation of bedside computer charting in an intensive care unit will be performed in this study. In a meta-analysis, the studies are the sample. No human subjects will be involved in the research.

2. What are the potential risks to the human subjects involved in this research or investigation (use continuation pages if necessary)?

None.

3. Is research being conducted for a nonuniversity sponsor? Yes ______ No X

Name of sponsor: ______

I certify that this research meets the requirements for being exempt from review by the HSRC as specified in the Human Subjects Program Guideline (March 1986, revised). Three committee members sign for professional paper or thesis, and all committee members sign for the dissertation research.

Dissertation/Theses signature page is here.

To protect individuals we have covered their signatures.

APPENDIX E

Meta-analysis Code Book

Group A: Direct Care

Activity 1: Assessment

1.1 – Vital signs
1.2 – Systems assessment
1.3 – Hemodynamic readings/ICP readings
1.4 – Cardiac output
1.5 – I&O/Measuring
1.6 – Admission assessment
1.7 – Weight
1.8 – Special: Crisis

Activity 2: ADL

2.1 – Bath
2.2 – Mouth care
2.3 – Peri care/Foley care
2.4 – Bed/Linen change
2.5 – Turns
2.6 – Elimination – Urine
2.7 – Elimination – Bowel
2.8 – Emesis
2.9 – Tube feedings
2.10 – Total feed/Assist
2.11 – Set–up tray
2.12 – Special/Calorie counts
2.13 – Activity/Mobility/PROM
2.14 – Chair/Transfer
2.15 – Adaptive equipment application
2.16 – Restraints
2.17 – Skin care/Rubs
2.18 – Shave
2.19 – Shampoo
2.20 – Comfort measures

Activity 3: Medications/IVs

3.1 – Oral/Rectal/Topical/Eye drops
3.2 – IV Meds/IM/SQ
3.3 – IV fluids/Hanging/Checking/Tubing change/DC
3.4 – Blood and blood products

Activity 4: Procedures

4.1 – Suctioning
4.2 – Ventilator check/Trouble–shoot
4.3 – Lab specimen collections
4.4 – Accucheck
4.5 – Specific gravity
4.6 – Ventricular/Lumbar drain management
4.7 – Oxygen set–up/Check
4.8 – Respiratory care/Treatments
4.9 – Tube repositioning
4.10 – Trach care
4.11 – Intubation/Extubation
4.12 – Line insertion/DC
4.13 – Set–up/Trouble–shoot lines
4.14 – Heating/Cooling blanket
4.15 – Dressing changes
4.16 – Irrigations
4.17 – Suture removal/Drain advance
4.18 – Ace bandages/TEDS
4.19 – Chest PT
4.20 – Decubitus care
4.21 – Death procedure
4.22 – Hot/Cold packs
4.23 – Ischemic foot care
4.24 – Organ procurement
4.25 – Ostomy care
4.26 – TENS
4.27 – Traction
4.28 – Transfer/Discharge activity
4.29 – Transfer on unit
4.30 – Transport to X–ray/Procedures
4.31 – Tube removal
4.32 – With patient while off unit
4.33 – Additional procedures: (specify)

Activity 5: Communication/ Psychosocial

5.1 – Patient/Family teaching
5.2 – Patient/Family interaction

Group B: Indirect Care

Activity 6: Documentation

6.1 – Vital signs
6.2 – Hemodynamics
6.3 – Neuro vital signs
6.4 – I&O/Drips
6.5 – Labs
6.6 – Systems assessment
6.7 – Treatment/Care/Equipment
6.8 – Nurses Notes
6.9 – Medications
6.10 – Care plan
6.11 – Graphic sheet
6.12 – Treatment Kardex
6.13 – Med Kardex
6.14 – Admission data base

Activity 7 Other Indirect Care

7.1 – Hand washing
7.2 – Phone calls
7.3 – Report
7.4 – Orders transcription/Check
7.5 – Patient classification
7.6 – Other HIS functions/Check lab results/Drip calculations
7.7 – Staffing/Assignment
7.8 – Narcotic/Emergency equipment checks
7.9 – Sending lab specimens
7.10 – Obtain/Refund supplies
7.11 – Written communication
7.12 – Informal consults
7.13 – Physician rounds/Consults
7.14 – Patient care conference formal/Informal
7.15 – Cleaning of unit
7.16 – Restocking
7.17 – Linen hampers
7.18 – Orientation of new staff
7.19 – Errands off unit
7.20 – Waiting
7.21 – No activity/No duties

Group C: Miscellaneous

Activity 8: Miscellaneous

8.1 – Breaks
8.2 – Committee meetings
8.3 – Committee work
8.4 – Evaluations
8.5 – Inservices
8.6 – Personal phone calls
8.7 – QI activities
8.8 – Staff meetings

Prepared by Management Systems Consulting
6–2–92

THE META-ANALYSIS CODEBOOK

Study code:

Length of time between pre- and post-study (in weeks):

1. Date of pre-study:
2. Date of post-study:

Applications in place at time of post-study:

1. Vital signs
2. Vital signs and I&O
3. Vital signs, I&O, and nurses notes
4. Vital signs, I&O, nurses notes, and others

Prior use of computers on unit:

1. No prior use of computers
2. Results reporting
3. Order entry and results reporting
4. Order entry, results reporting, and others

Quality of study:

1. Observer training
2. Observer training and practice
3. Observer training, practice, and interrater reliability testing

---

	X(b)	X(a)	%(b)	%(a)	%(c)
Direct patient care:					
Indirect patient care:					
Communication:					
Charting:					

APPENDIX F

Approval to Conduct Study

TEXAS WOMAN'S
UNIVERSITY
DENTON / DALLAS / HOUSTON

THE GRADUATE SCHOOL
P.O. Box 22479
Denton, TX 76204-0479
Phone: 817/898-3400
Fax: 817/898-3412

March 10, 1994

Ms. Pamela Salyer
8918 Bissonnet, Condo 103
Houston, TX 77074

Dear Ms. Salyer:

I have received and approved the Prospectus for your research project. Best wishes to you in the research and writing of your project.

Sincerely yours,

Dissertation/Theses signature page is here.

To protect individuals we have covered their signatures.